DRAFT REPORT

Emission Inventories and Potential Emission Control Strategies For Ozone Early Action Compact Areas in Tennessee

Report Prepared for

Tennessee Department of Transportation
Division of Transportation Planning

and

Tennessee Department of Environment and Conservation
Division of Air Pollution Control

by

The University of Tennessee
Department of Civil and Environmental Engineering

April 13, 2003

For additional information or electronic copies of this report:
Contact: Wayne T. Davis, wtdavis@utk.edu or
Terry L. Miller, tmiller3@utk.edu
Telephone: (865)974-7728

DRAFT REPORT

Emission Inventories and Potential Emission Control Strategies for Ozone Early Action Compact Areas in Tennessee

1. Introduction

The University of Tennessee in cooperation with the TDEC Division of Air Pollution Control and the Tennessee Department of Transportation has prepared this draft report to assist Early Action Compact areas and the state in making decisions regarding potential control strategies that might be considered in meeting the 8-hr ozone standard by 2007. This report includes information on the emission inventories for 1999 and 2007 (Section 2.1) for NOx, a preliminary summary of the most recent ozone modeling effort (Section 2.2), and a summary of potential control strategies (Section 2.3). TDOT requested that the university provide additional information on the potential control strategies, including Transportation Control Measures (TCMs), that might be considered by the various air quality agencies, Metropolitan Planning Organizations (MPOs), and other entities involved in providing input on the strategies that might be used. Section 3 of the report provides a more detailed discussion of each of the control strategies, including, where possible, a discussion the emission reductions that can be achieved by each strategy, the cost of each strategy, and the policy issues associated with each strategy.

The emission inventory information included in Section 2.1 of this report is based on the Tier 1 emission inventories that are reported on the U.S. EPA website: www.epa.gov/air/data for the state and county-level for 1999. The emission inventory was modified to incorporate the MOBILE6-based on-road emissions, based on the report, "Effects of Growth in VMT and New Mobile Source Emission Standards on NO_x and VOC Emissions in Tennessee 1999-2030" dated March 12, 2002 and prepared by the university for TDOT. The inventories were developed for the state and each Early Action Compact area in the state. The focus of the inventories presented herein is primarily on NOx due to the NOx limited nature of the ozone problem in TN and the short period of time available to prepare the report. It is recognized, however, that strategies that reduce VOCs may also reduce ozone concentrations. Emission inventories for VOCs can be obtained from the above web site for all major anthropogenic source categories in TN and supplemented by the updated MOBILE source emission inventories found in the above referenced TDOT report. The 1999 inventories were then projected to 2007. The estimated 2007 inventories incorporate the effect of the NO_x SIP call, which places restrictions on NO_x emissions from electric generating units and specific large industrial boilers. Tables have been prepared showing the estimated emissions of NOx from the major source categories for 1999 and 2007 for the state and for each county within each EAC. Pie charts have been prepared for the state and each EAC showing the percentage of emissions of NOx contributed by each source category. Bar charts have been prepared to show the approximate fraction of on-road mobile source emissions contributed by each vehicle classification type for 2007. Vehicle classifications include light duty gasoline vehicles (LDGV--primarily automobiles), LDGT12 (pickups, minivans, SUVs with gross vehicle weight rating <6500 lbs), LDGT34 (intermediate weight gasoline powered vans, SUVs, trucks with gross vehicle weight ratings of 6000-8500), HDGV (heavy duty gasoline vehicles >8500), MC (motorcycles), LDDV (light duty diesel vehicles), LDDT (light duty diesel trucks), and HDDV (heavy duty diesel vehicles, i.e. transfer trucks).

A key component of the development of the control strategies required to meet the 8-hr ozone standard is the photochemical modeling being conducted by SAI through the Arkansas Tennessee Mississippi Ozone Study (ATMOS). The modeling effort was initially conducted for the 1999 Basecase Year for a 12 day episode (Aug 29 – Sept 9, 1999), followed by projections to the year 2010, in anticipation that areas would be designated nonattainment with an estimated 2010 reattainment deadline. The decision to pursue attainment by 2007 under the Early Action Compact (EAC) program requires modeling the Baseline year of 2007. To that end, SAI completed its first modeling run for the 2007 Baseline in early April 2003. A second modeling episode is planned using a Basecase year in the 2000 to 2002 period. The Baseline 2007 modeling run includes all of the emission reductions that are already required for 2007 under the NOx SIP call, the Federal Motor Vehicle Control Program, and all regulations that are currently required to be met by the 2007 attainment year. Modeling for 2007 has not yet been conducted to determine the effect of any proposed control strategies that might be considered by the state or the EACs. The obvious question is, "How much additional reduction in precursor emissions does the state and/or each EAC need to meet the standard by 2007?" While this question cannot be answered until control strategies have been identified and modeled, a preliminary analysis of the 2007 modeling results has been made and very precursory estimates have been made as to whether each EAC has met the 85 ppb design value requirement at the monitoring stations in each EAC. While this is only one of many metrics that must be considered, it provides some insight into whether the area is close to meeting the standard and how much additional reduction may be needed. This is summarized in Section 2.2.

Section 2.3 of the report includes a preliminary summary of potential emission reduction actions that have been proposed by various air quality and transportation management agencies, U.S. EPA and others. An effort has been made to review each potential action, to identify the potential emission reductions that might be achieved by implementing the strategy, to quantify the cost in $/ton of NOx reduced, and to identify policy issues that would need to be addressed. Detailed calculations are included in Section 3.

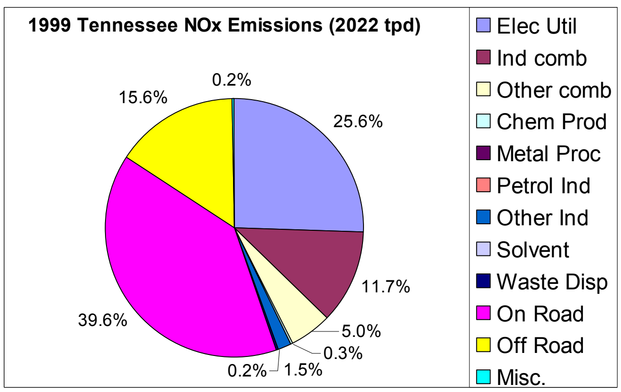
The intent of the report is to provide information within Sections 2.1, 2.2, and 2.3 to assist all parties in compiling a list of strategies that might be needed to meet the standard by 2007. Additional potential strategies are welcomed and the university will make every effort to quantify additional strategies within the limitation of available information

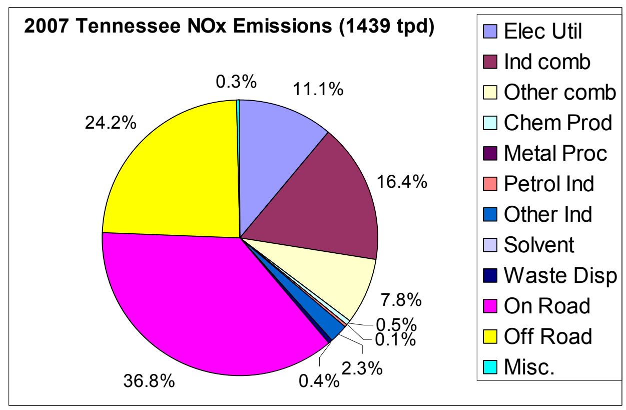
2. Summary of Results

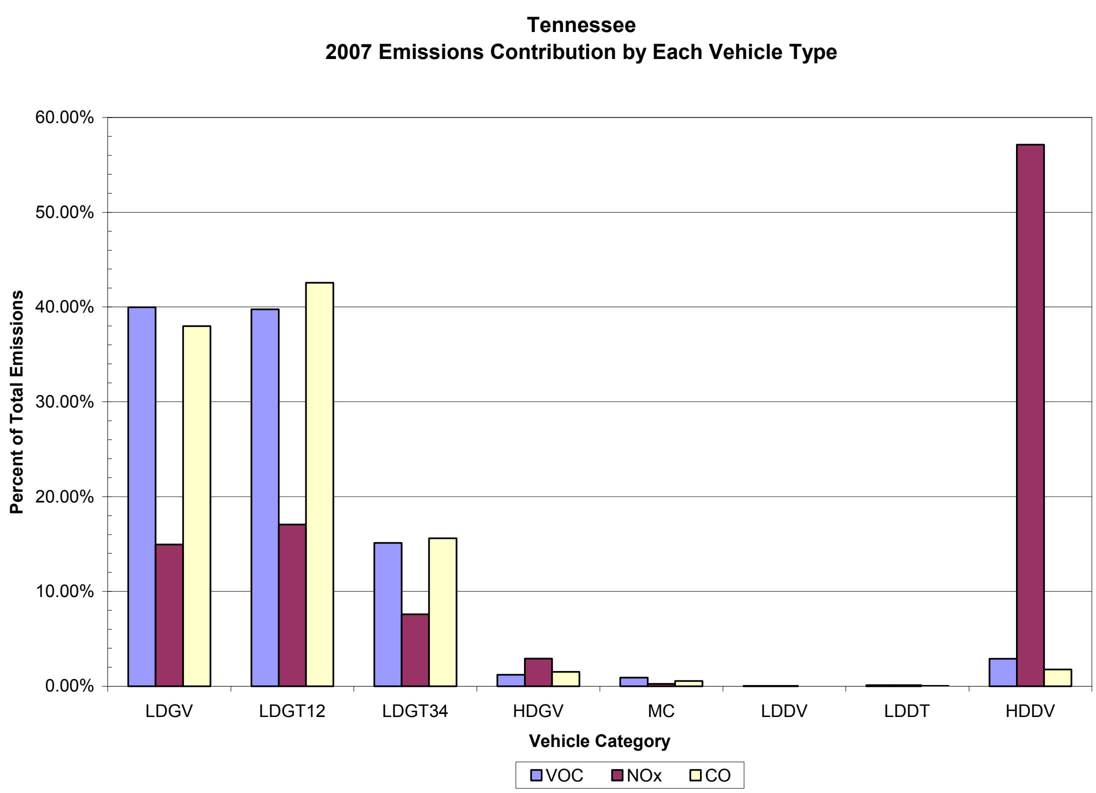
2.1. State-wide and EAC Emission Inventories

NOx Emissions for Tennessee (Ozone Season Day)

Source	1999 Tons/day	%	2007 Tons/day	%
Elec Util	518.2	25.6	160.0	11.1
Ind comb	237.1	11.7	235.9	16.4
Other comb	101.3	5.0	111.9	7.8
Chem Prod	7.0	0.3	7.8	0.5
Metal Proc	1.8	0.1	2.0	0.1
Petrol Ind	1.3	0.1	1.4	0.1
Other Ind	30.6	1.5	33.8	2.3
Solvent	0.2	0.0	0.3	0.0
Waste Disp	4.9	0.2	5.4	0.4
On Road	801.4	39.6	529.1	36.8
Off Road	314.7	15.6	347.7	24.2
Misc.	3.3	0.2	3.7	0.3
Total:	2021.8	100.0	1439.1	100.0





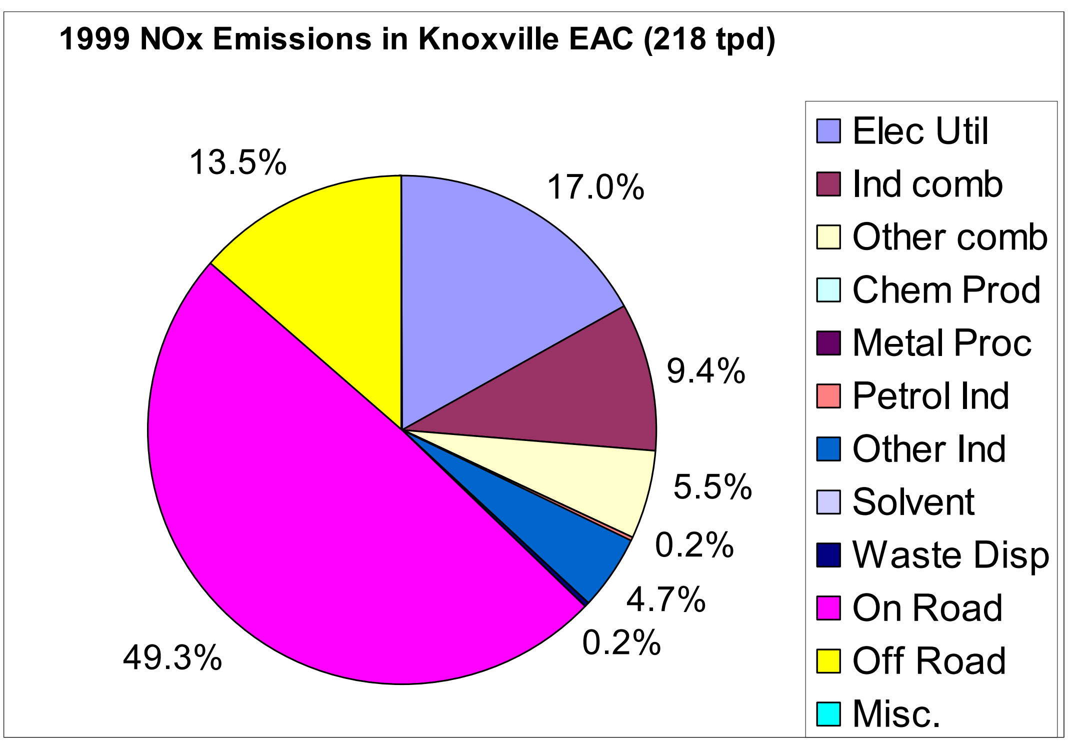


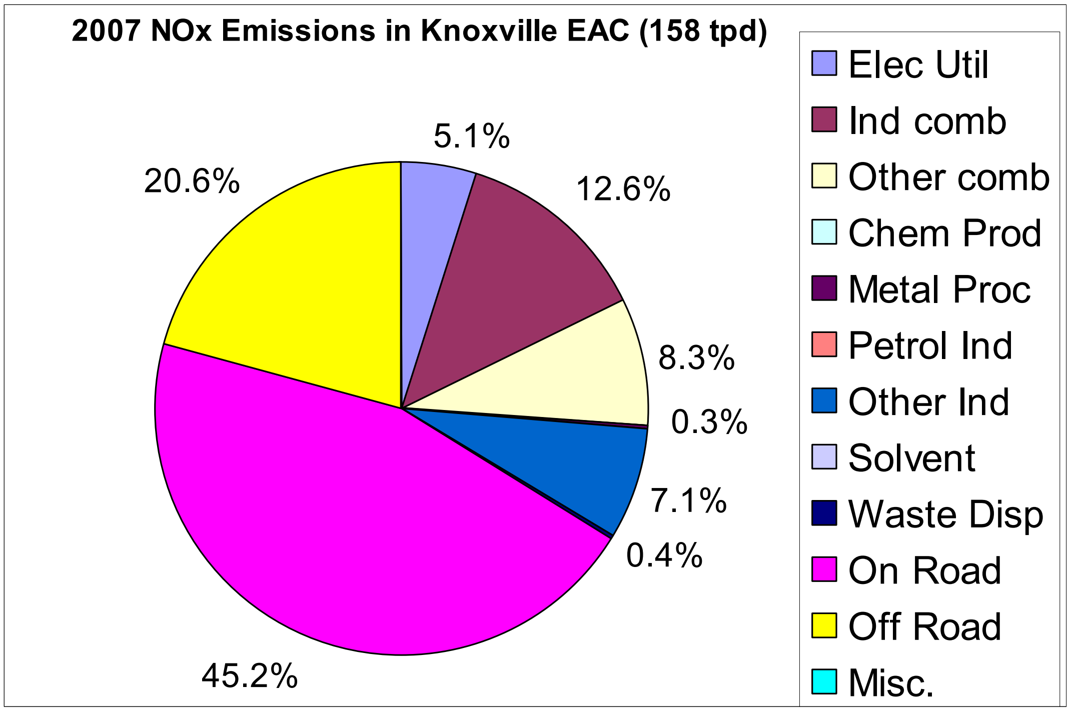
1999 Knoxville Area EAC Emissions (tons/day)

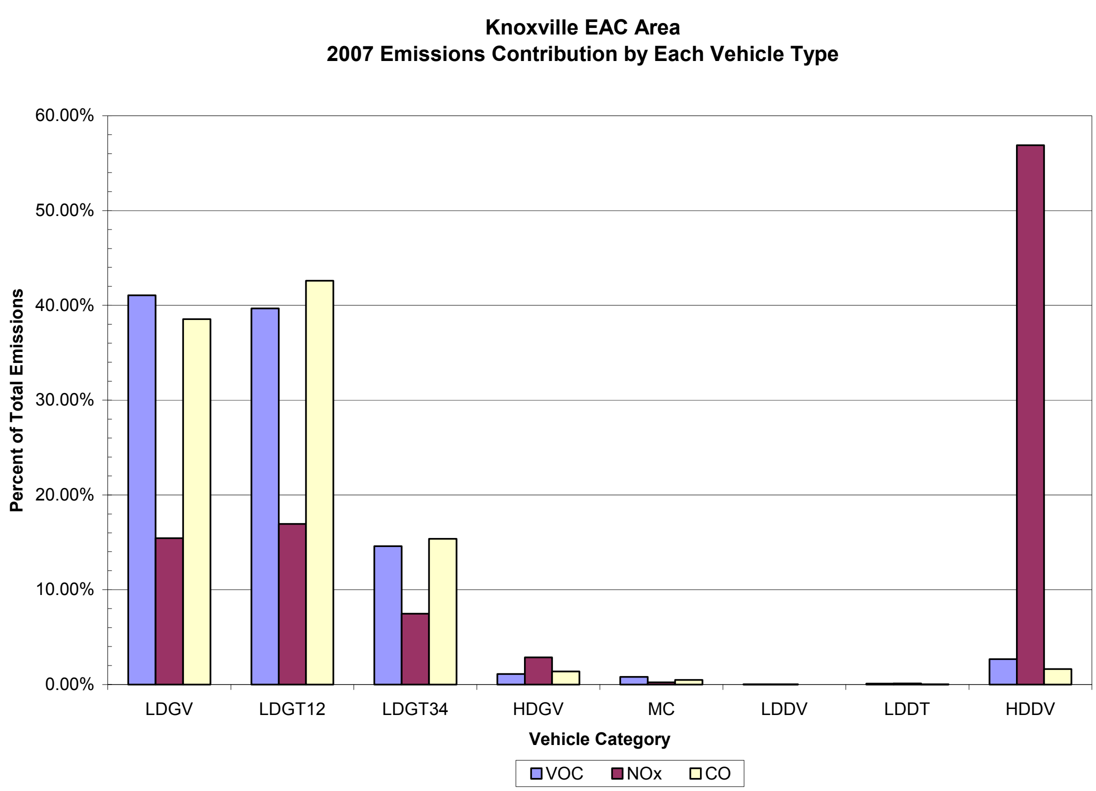
	Anderson	Blount	Jefferson	Knox	Loudon	Sevier	Union	Total	Percent
Elec Util	37.1	0.0	0.0	0.0	0.0	0.0	0.0	37.1	17.0
Ind comb	4.8	6.4	0.0	5.3	3.7	0.1	0.1	20.5	9.4
Other comb	0.2	0.2	0.1	11.1	0.1	0.2	0.0	11.9	5.5
Chem Prod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metal Proc	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.4	0.2
Petrol Ind	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Other Ind	0.1	0.0	0.0	8.8	0.0	0.0	1.3	10.2	4.7
Solvent	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Waste Disp	0.1	0.1	0.1	0.2	0.0	0.1	0.0	0.5	0.2
On Road	10.1	6.3	14.6	54.3	13.0	8.2	0.9	107.4	49.3
Off Road	2.6	4.2	1.5	16.5	1.9	2.2	0.5	29.5	13.5
Misc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
	55.0	17.8	16.2	96.4	18.8	10.8	2.9	217.9	100.0

2007 Knoxville Area EAC Emissions (tons/day)

	Anderson	Blount	Jefferson	Knox	Loudon	Sevier	Union	Total	Percent
Elec Util	8.10	0.00	0.00	0.00	0.00	0.00	0.00	8.10	5.1
Ind comb	4.09	7.07	0.03	5.91	2.65	0.14	0.07	19.96	12.6
Other comb	0.25	0.23	0.08	12.29	0.07	0.19	0.04	13.15	8.3
Chem Prod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Metal Proc	0.00	0.38	0.00	0.06	0.00	0.00	0.00	0.45	0.3
Petrol Ind	0.00	0.12	0.00	0.02	0.00	0.00	0.00	0.14	0.1
Other Ind	0.13	0.01	0.00	9.69	0.02	0.00	1.43	11.29	7.1
Solvent	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07	0.0
Waste Disp	0.06	0.08	0.06	0.24	0.04	0.07	0.03	0.58	0.4
On Road	6.17	4.77	9.81	35.64	8.38	6.08	0.64	71.49	45.2
Off Road	2.91	4.68	1.67	18.19	2.14	2.41	0.59	32.59	20.6
Misc.	0.04	0.04	0.04	0.02	0.01	0.03	0.00	0.18	0.1
	21.74	17.38	11.69	82.15	13.31	8.92	2.81	157.99	100.0




2007 NOx Emissions in Knoxville EAC (158 tpd)
5.1%
12.6%
8.3%
0.3%
7.1%
0.4%
45.2%
20.6%
Elec Util
Ind comb
Other comb
Chem Prod
Metal Proc
Petrol Ind
Other Ind
Solvent
Waste Disp
On Road
Off Road
Misc.

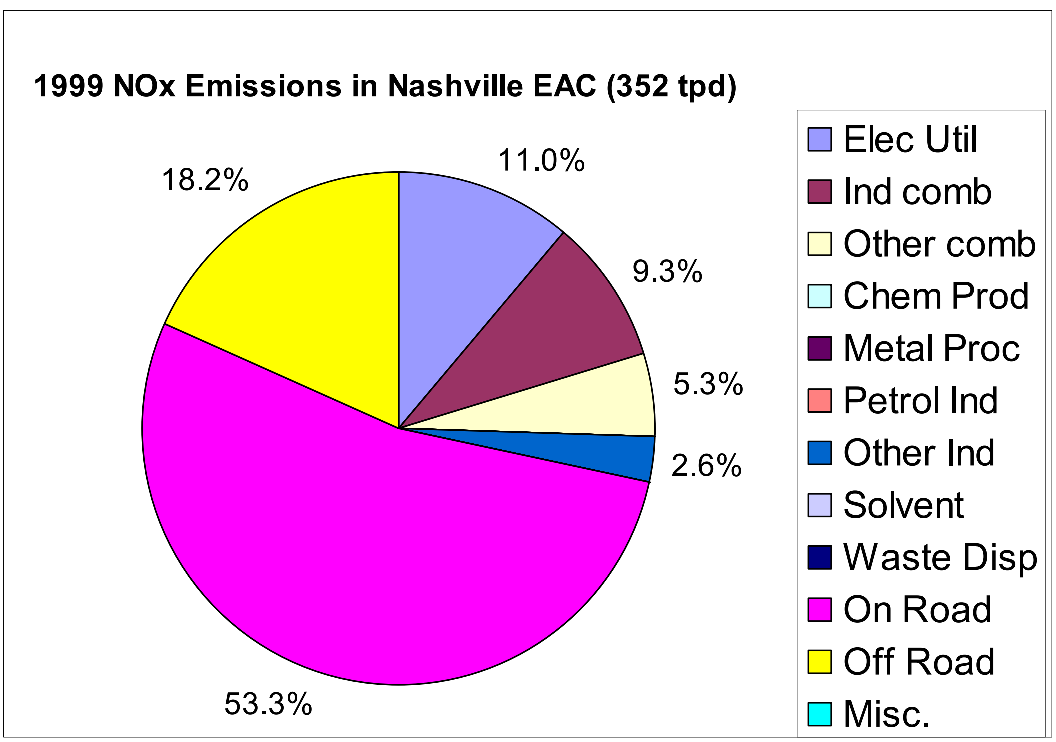

Knoxville EAC Area
2007 Emissions Contribution by Each Vehicle Type
Percent of Total Emissions
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
LDGV
LDGT12
LDGT34
HDGV
MC
LDDV
LDDT
HDDV
Vehicle Category
VOC
NOx
CO

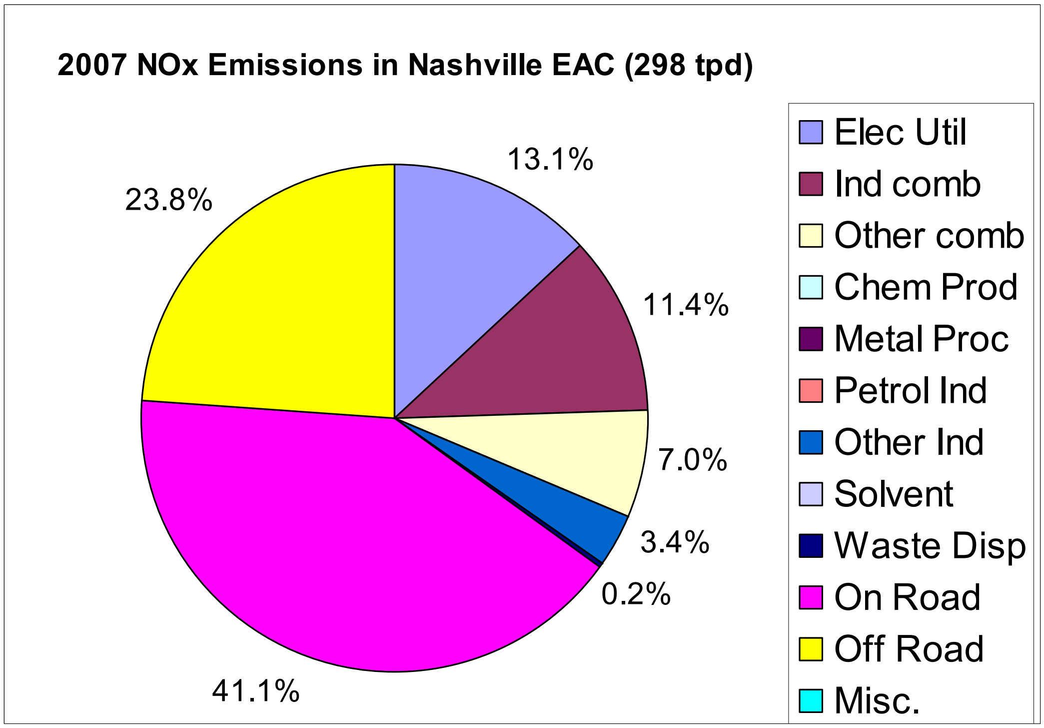
1999 Nashville Area EAC Emissions in Tons/day

	Cheatham	Davidson	Dickson	Robertson	Rutherford	Sumner	Williamson	Wilson	Total
Elec Util	0.00	0.00	0.00	0.00	0.00	38.92	0.00	0.00	38.92
Ind comb	0.12	7.22	0.66	0.60	2.55	18.55	0.87	2.20	32.76
Other comb	0.11	16.30	0.18	0.17	0.53	0.75	0.41	0.27	18.72
Chem Prod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Proc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petrol Ind	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Other Ind	0.03	9.08	0.01	0.00	0.06	0.00	0.00	0.00	9.19
Solvent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Disp	0.05	0.00	0.06	0.06	0.17	0.11	0.13	0.09	0.67
On Road	8.83	79.67	9.47	18.22	25.77	13.03	16.14	16.85	187.98
Off Road	2.09	30.04	1.94	2.46	8.87	6.63	8.09	3.91	64.04
Misc.	0.01	0.03	0.04	0.01	0.02	0.05	0.02	0.00	0.19
	11.25	142.35	12.36	21.52	37.97	78.04	25.65	23.33	352.48

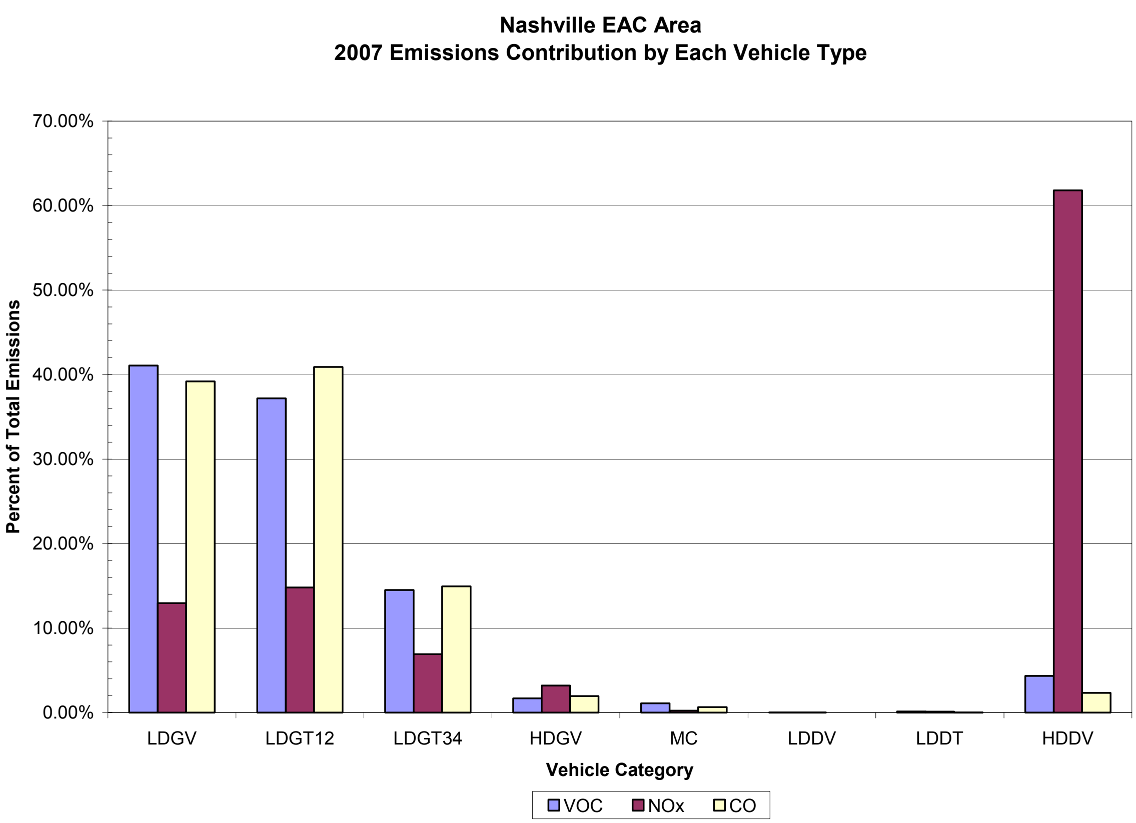
2007 Nashville Area EAC Emissions (tons/day)

	Cheatham	Davidson	Dickson	Robertson	Rutherford	Sumner	Williamson	Wilson	Total
Elec Util	0.00	0.00	0.00	0.00	0.00	38.92	0.00	0.00	38.92
Ind comb	0.14	5.57	0.73	0.66	2.82	20.49	0.96	2.43	33.79
Other comb	0.12	18.01	0.20	0.19	0.59	0.82	0.46	0.30	20.69
Chem Prod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Proc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petrol Ind	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Other Ind	0.04	10.04	0.01	0.00	0.07	0.00	0.00	0.00	10.15
Solvent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Disp	0.06	0.00	0.06	0.07	0.18	0.12	0.14	0.10	0.74
On Road	5.92	51.44	6.15	11.81	17.07	8.40	10.80	10.79	122.38
Off Road	2.31	33.20	2.14	2.72	9.81	7.33	8.94	4.32	70.77
Misc.	0.02	0.04	0.05	0.02	0.02	0.05	0.02	0.00	0.21
	8.60	118.30	9.35	15.46	30.55	76.14	21.31	17.95	297.66





2007 NOx Emissions in Nashville EAC (298 tpd)
13.1%
11.4%
7.0%
3.4%
0.2%
41.1%
23.8%
Elec Util
Ind comb
Other comb
Chem Prod
Metal Proc
Petrol Ind
Other Ind
Solvent
Waste Disp
On Road
Off Road
Misc.



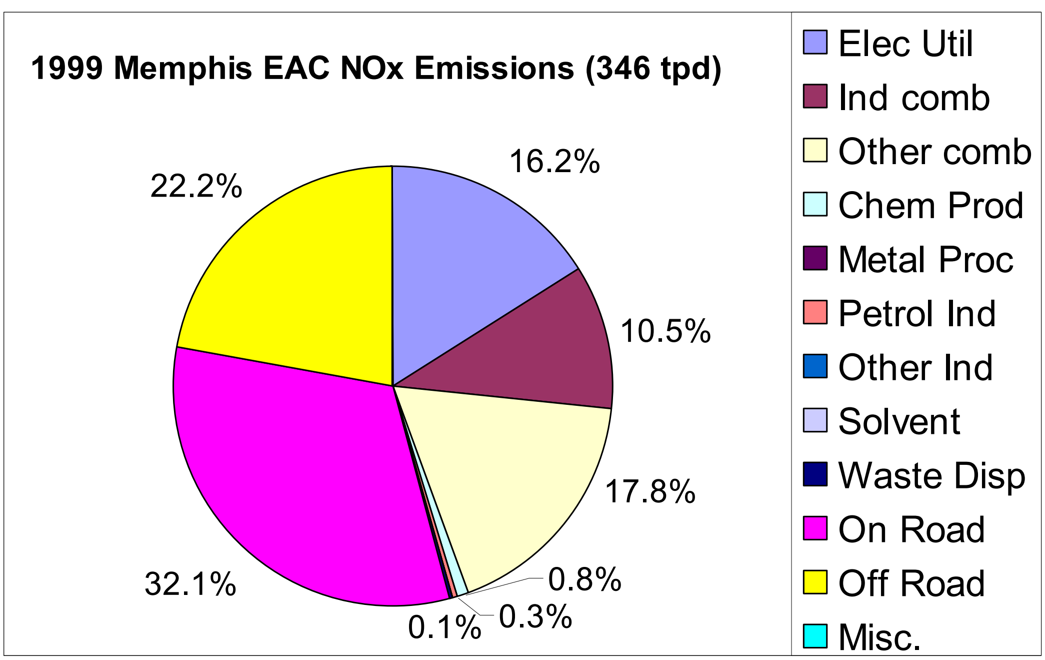
Nashville EAC Area
2007 Emissions Contribution by Each Vehicle Type
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Percent of Total Emissions
LDGV
LDGT12
LDGT34
HDGV
MC
LDDV
LDDT
HDDV
Vehicle Category
VOC
NOx
CO

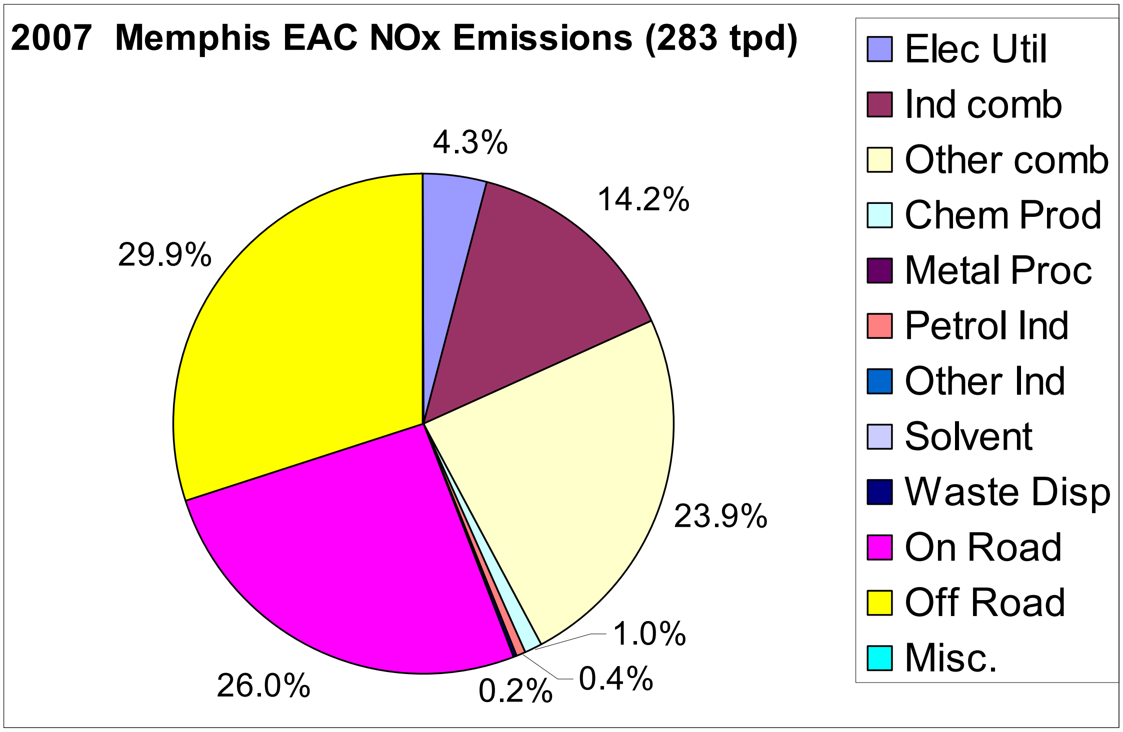
1999 Memphis EAC Emissions (tons/day)

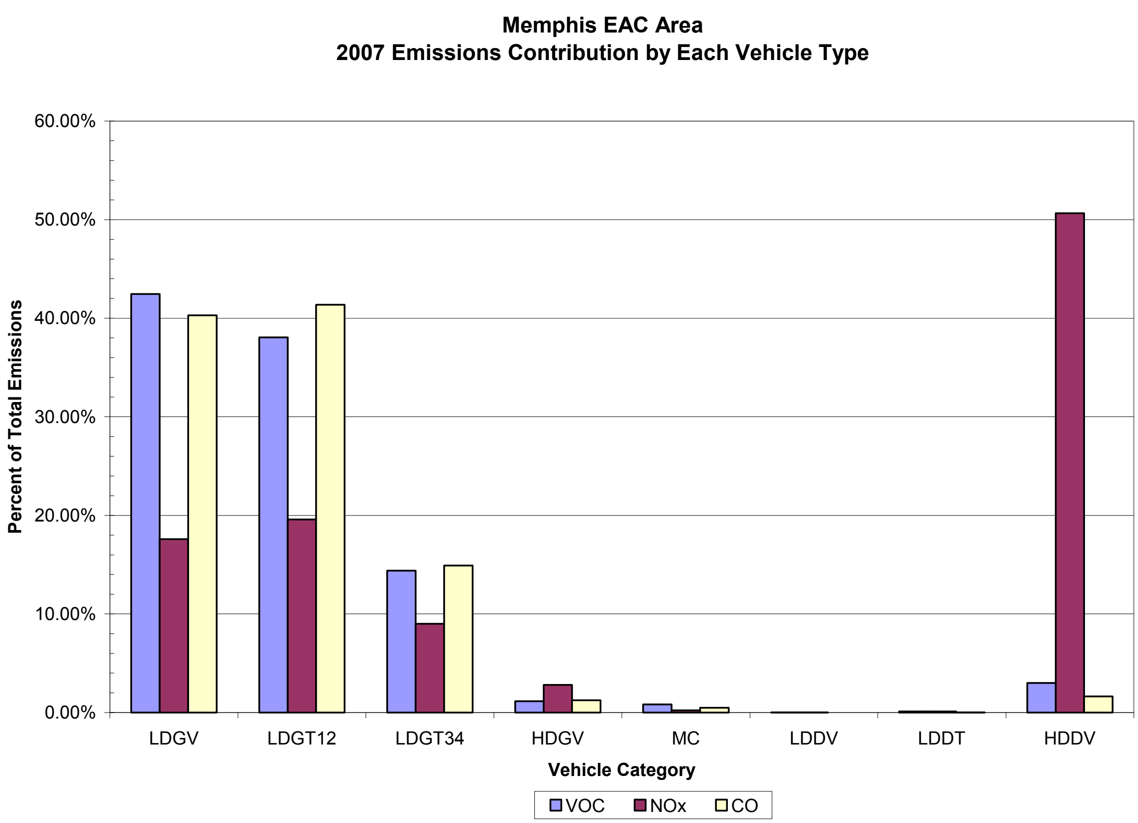
	Crittenden	DeSota	Fayette	Shelby	Tipton	Total	%
Elec Util	0.00	0.00	0.00	55.97	0.00	55.97	16.2
Ind comb	2.79	1.80	0.24	26.79	4.75	36.36	10.5
Other comb	0.28	1.37	0.06	59.74	0.06	61.51	17.8
Chem Prod	0.00	0.00	0.00	2.61	0.00	2.61	0.8
Metal Proc	0.00	0.05	0.00	0.00	0.00	0.05	0.0
Petrol Ind	0.00	0.00	0.00	0.93	0.00	0.93	0.3
Other Ind	0.19	0.00	0.00	0.00	0.00	0.19	0.1
Solvent	0.00	0.07	0.00	0.00	0.00	0.07	0.0
Waste Disp	0.02	0.07	0.04	0.36	0.05	0.54	0.2
On Road	11.12	12.41	10.24	74.83	2.40	110.99	32.1
Off Road	6.99	6.43	2.06	55.16	6.10	76.75	22.2
Misc.	0.00	0.00	0.01	0.07	0.01	0.10	0.0
	21.39	22.20	12.66	276.47	13.37	346.09	100.0

2007 Memphis Area EAC Emissions (tons/day)

	Crittenden	DeSota	Fayette	Shelby	Tipton	Total	%
Elec Util	0.00	0.00	0.00	12.10	0.00	12.10	4.3
Ind comb	3.08	1.99	0.26	29.61	5.24	40.18	14.2
Other comb	0.31	1.51	0.07	66.01	0.07	67.97	23.9
Chem Prod	0.00	0.00	0.00	2.89	0.00	2.89	1.0
Metal Proc	0.00	0.06	0.00	0.00	0.00	0.06	0.0
Petrol Ind	0.00	0.00	0.00	1.02	0.00	1.02	0.4
Other Ind	0.21	0.00	0.00	0.00	0.00	0.21	0.1
Solvent	0.00	0.08	0.00	0.00	0.00	0.08	0.0
Waste Disp	0.02	0.08	0.05	0.39	0.06	0.60	0.2
On Road	7.23	8.07	6.60	50.27	1.70	73.86	26.0
Off Road	7.72	7.11	2.28	60.96	6.74	84.81	29.9
Misc.	0.00	0.00	0.02	0.08	0.01	0.11	0.0
	18.58	18.89	9.28	223.33	13.82	283.89	100.0




2007 Memphis EAC NOx Emissions (283 tpd)
4.3%
14.2%
29.9%
23.9%
1.0%
0.4%
0.2%
26.0%
Elec Util
Ind comb
Other comb
Chem Prod
Metal Proc
Petrol Ind
Other Ind
Solvent
Waste Disp
On Road
Off Road
Misc.

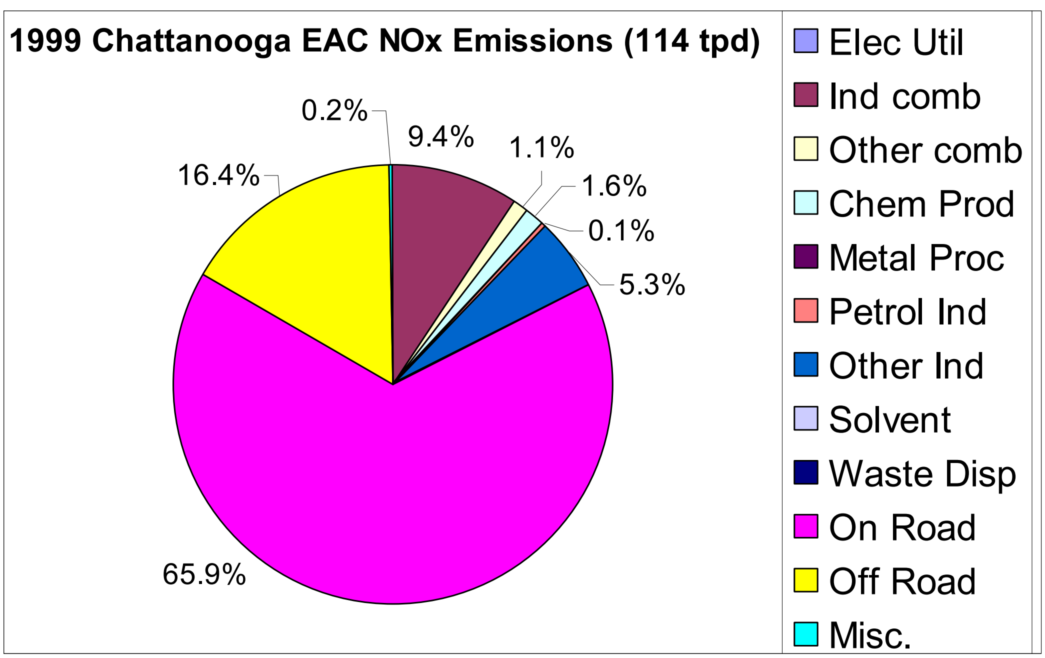

Memphis EAC Area
2007 Emissions Contribution by Each Vehicle Type
Percent of Total Emissions
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
LDGV
LDGT12
LDGT34
HDGV
MC
LDDV
LDDT
HDDV
Vehicle Category
VOC
NOx
CO

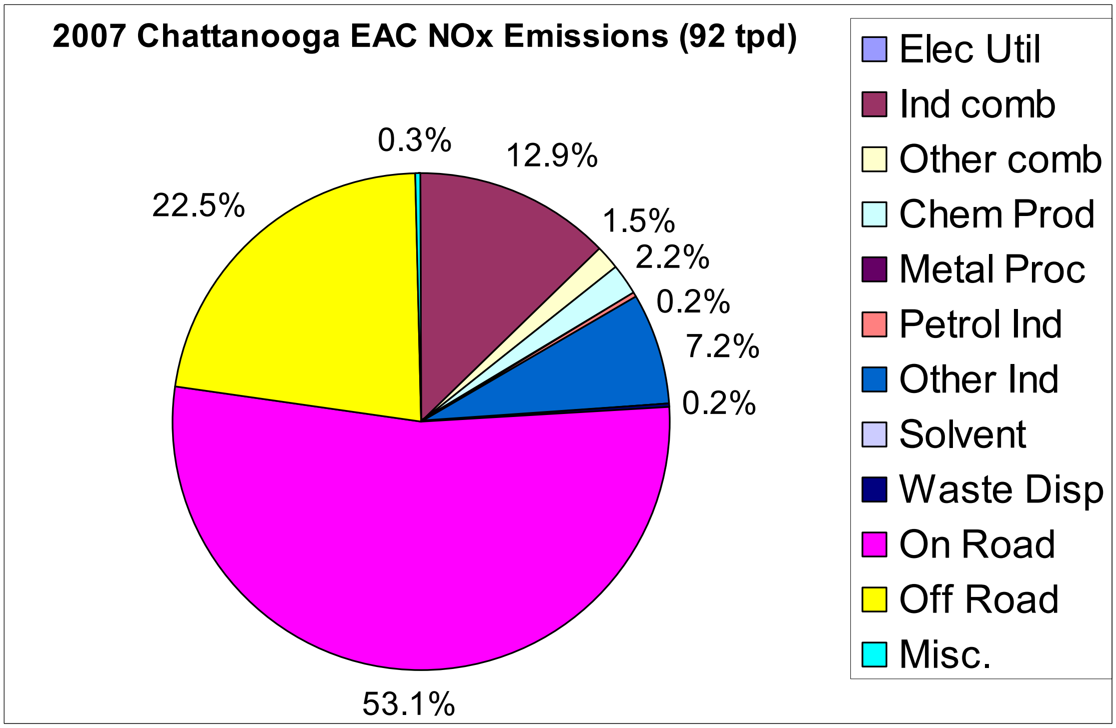
1999 Chattanooga Area EAC Emissions (tons/day)

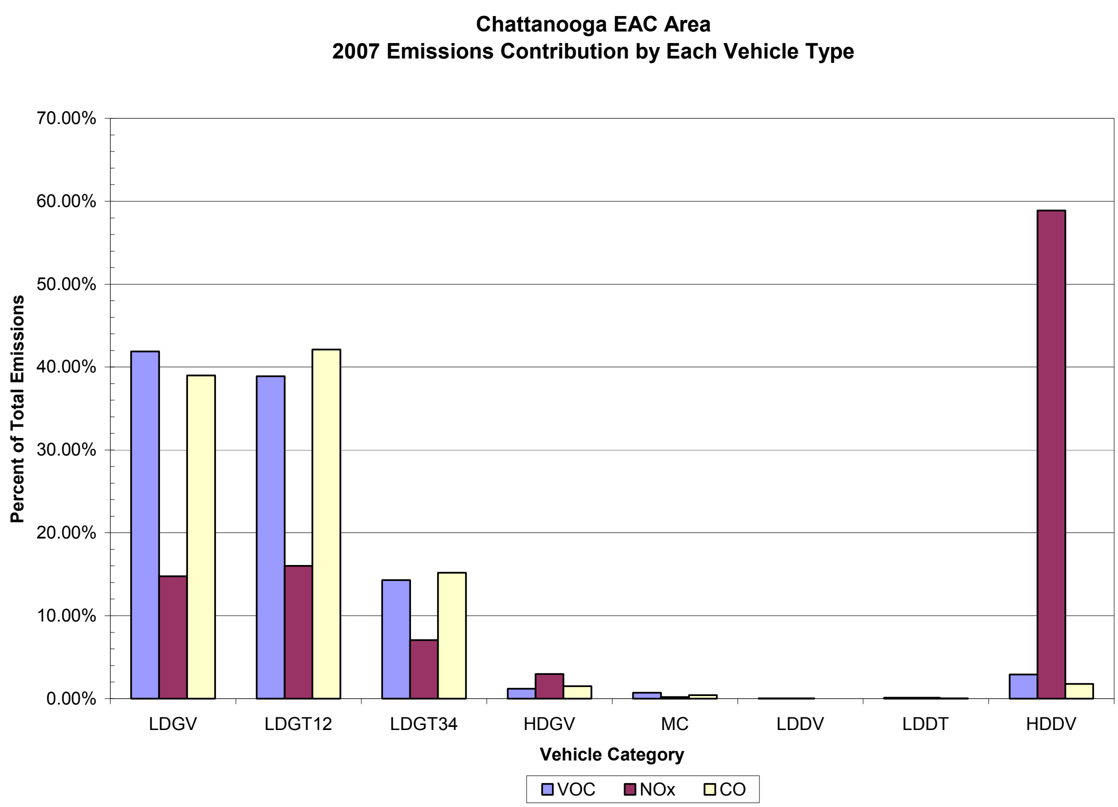
	Catoosa	Hamilton	Marion	Miegs	Walker	Total	%
Elec Util	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Ind comb	0.07	9.63	0.27	0.00	0.71	10.68	9.4
Other comb	0.07	0.92	0.12	0.02	0.10	1.22	1.1
Chem Prod	0.00	1.81	0.00	0.00	0.00	1.81	1.6
Metal Proc	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Petrol Ind	0.00	0.08	0.00	0.00	0.09	0.17	0.1
Other Ind	0.00	5.91	0.09	0.00	0.00	6.00	5.3
Solvent	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Waste Disp	0.03	0.02	0.04	0.01	0.04	0.14	0.1
On Road	8.70	41.94	15.73	0.74	8.01	75.13	65.9
Off Road	1.28	13.42	1.46	0.55	1.98	18.69	16.4
Misc.	0.03	0.05	0.05	0.01	0.09	0.23	0.2
	10.19	73.78	17.75	1.33	11.02	114.07	100.0

2007 Chattonooga Area EAC Emissions (tons/day)

	Catoosa	Hamilton	Marion	Miegs	Walker	Total	%
Elec Util	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Ind comb	0.08	10.64	0.29	0.00	0.78	11.80	12.9
Other comb	0.07	1.01	0.14	0.02	0.11	1.35	1.5
Chem Prod	0.00	2.00	0.00	0.00	0.00	2.00	2.2
Metal Proc	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Petrol Ind	0.00	0.08	0.00	0.00	0.10	0.19	0.2
Other Ind	0.00	6.53	0.10	0.00	0.00	6.63	7.2
Solvent	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Waste Disp	0.04	0.02	0.04	0.02	0.04	0.15	0.2
On Road	5.66	27.19	10.24	0.48	5.21	48.78	53.1
Off Road	1.41	14.83	1.62	0.60	2.19	20.65	22.5
Misc.	0.04	0.06	0.05	0.01	0.10	0.25	0.3
	7.30	62.37	12.47	1.13	8.53	91.81	100.0




2007 Chattanooga EAC NOx Emissions (92 tpd)
0.3%
12.9%
22.5%
1.5%
2.2%
0.2%
7.2%
0.2%
53.1%
Elec Util
Ind comb
Other comb
Chem Prod
Metal Proc
Petrol Ind
Other Ind
Solvent
Waste Disp
On Road
Off Road
Misc.

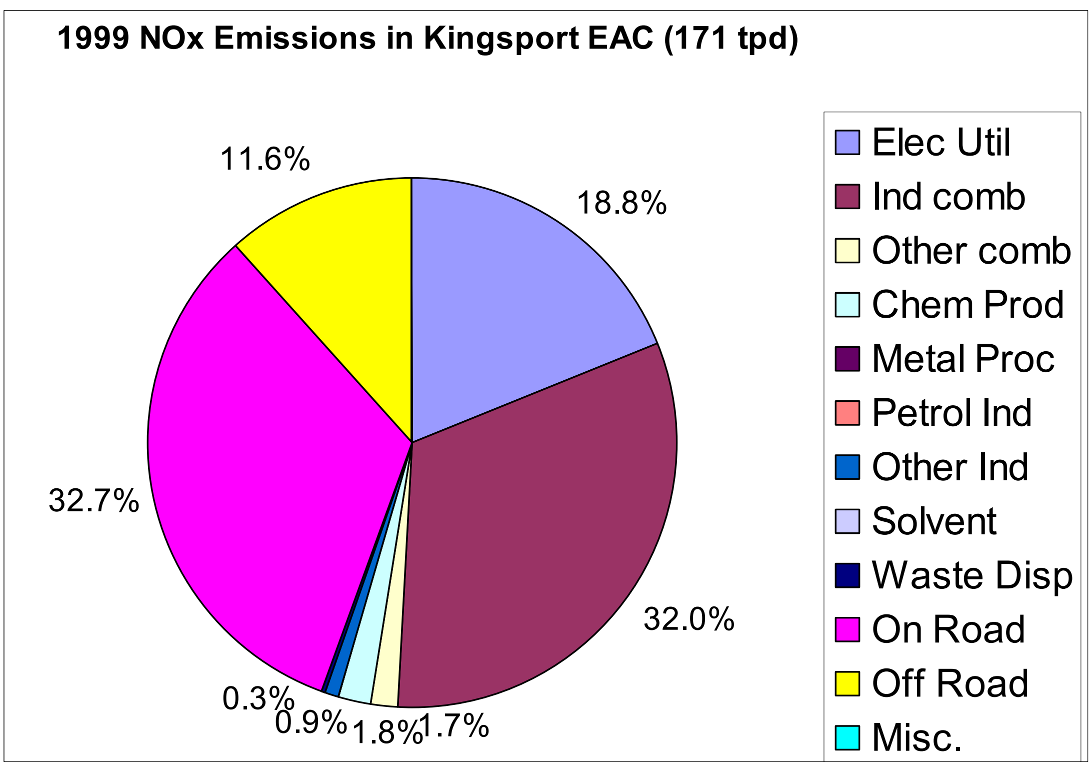

Chattanooga EAC Area
2007 Emissions Contribution by Each Vehicle Type
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Percent of Total Emissions
LDGV
LDGT12
LDGT34
HDGV
MC
LDDV
LDDT
HDDV
Vehicle Category
VOC
NOx
CO

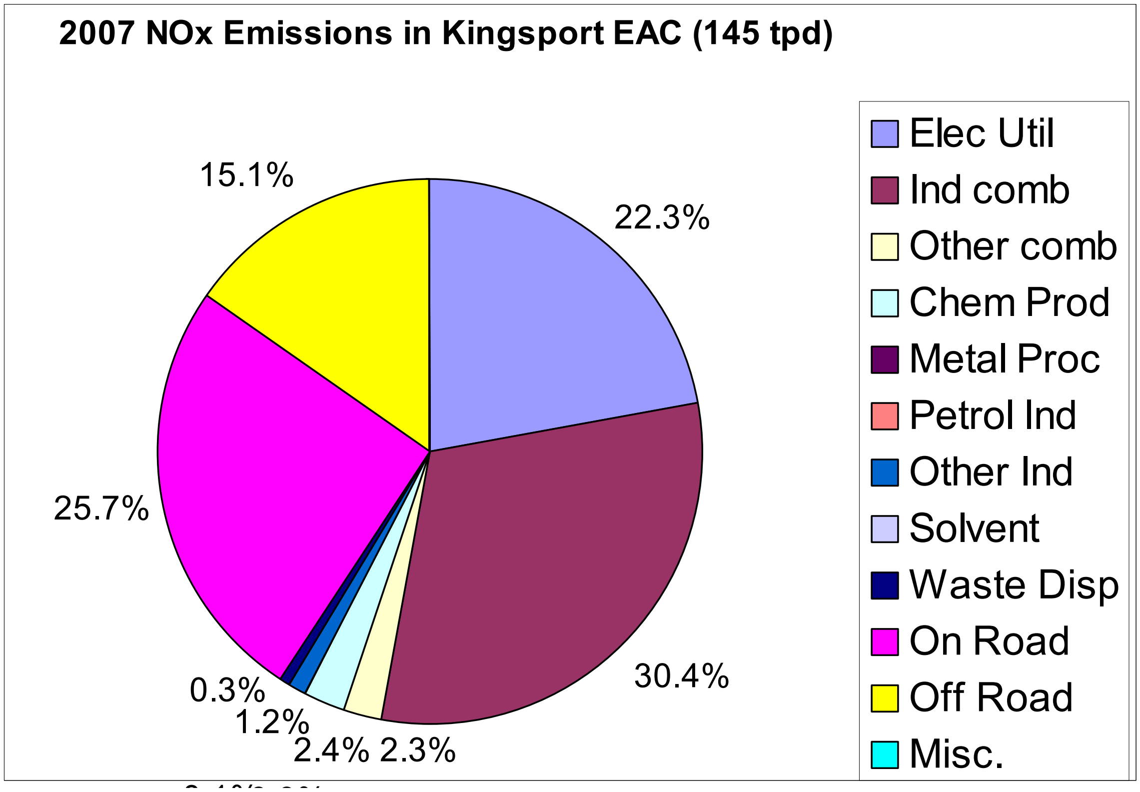
1999 Kingsport Area EAC Emissions (tons/day)

	Carter	Hawkins	Johnson	Scott VA	Sullivan	Unicoi	Wash. TN	Wash. VA	Total	%
Elec Util	0.00	32.27	0.00	0.00	0.00	0.00	0.00	0.00	32.27	18.8
Ind comb	1.32	2.08	0.23	0.22	48.72	0.01	0.50	1.74	54.82	32.0
Other coml	0.12	0.09	0.05	0.20	1.17	0.04	0.52	0.76	2.95	1.7
Chem Proc	0.00	2.12	0.00	0.00	1.04	0.00	0.00	0.00	3.16	1.8
Metal Proc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Petrol Ind	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	0.1
Other Ind	0.01	0.14	0.00	0.08	1.20	0.00	0.08	0.00	1.51	0.9
Solvent	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.04	0.0
Waste Disp	0.04	0.07	0.02	0.03	0.14	0.02	0.05	0.07	0.44	0.3
On Road	3.55	3.24	1.02	3.75	17.93	1.35	11.20	13.97	56.00	32.7
Off Road	1.67	2.52	0.67	0.93	6.39	0.67	4.84	2.13	19.82	11.6
Misc.	0.01	0.02	0.02	0.01	0.01	0.01	0.08	0.00	0.16	0.1
	6.91	42.56	2.03	5.23	76.62	2.10	17.26	18.67	171.37	100.0

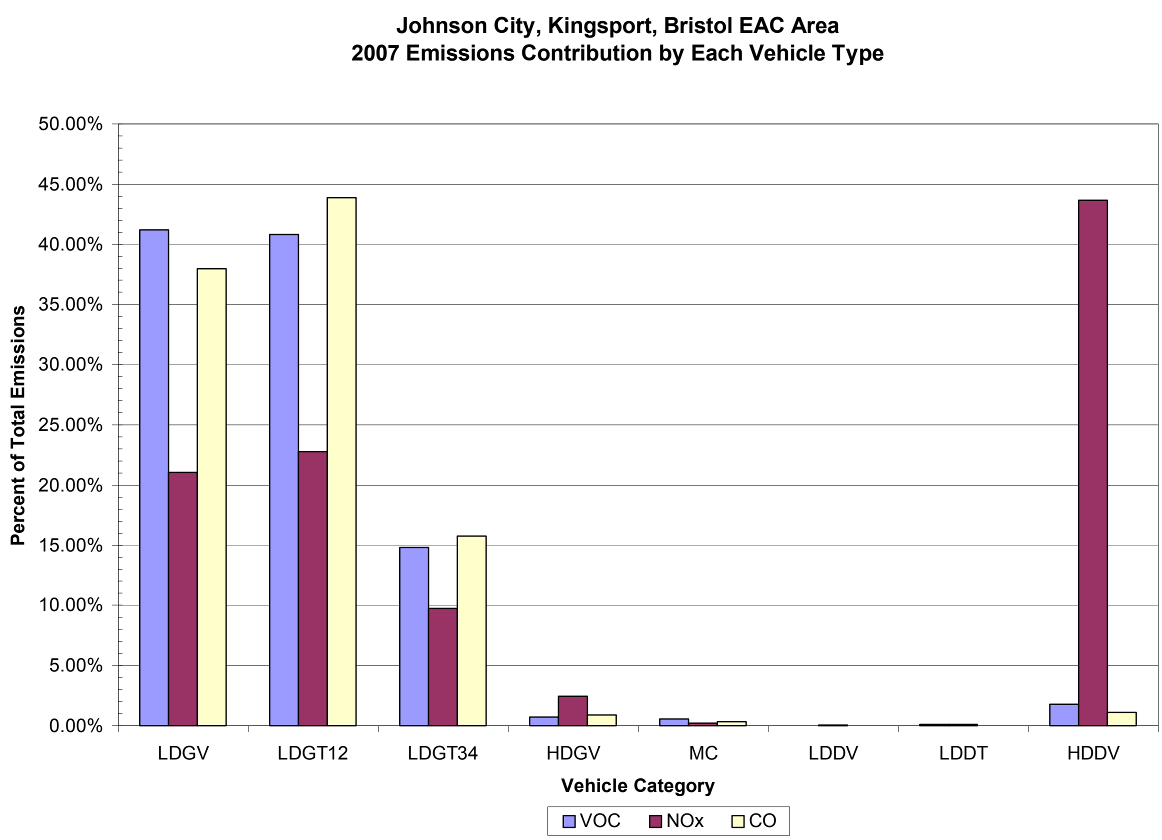
2007 Kingsport Area EAC Emissions (tons/day)

	Carter	Hawkins	Johnson	Scott VA	Sullivan	Unicoi	Wash. TN	Wash. VA	Total	%
Elec Util	0.00	32.27	0.00	0.00	0.00	0.00	0.00	0.00	32.3	22.3
Ind comb	1.46	2.30	0.26	0.25	37.25	0.01	0.55	1.92	44.0	30.4
Other coml	0.13	0.10	0.06	0.22	1.29	0.04	0.58	0.84	3.3	2.3
Chem Proc	0.00	2.34	0.00	0.00	1.15	0.00	0.00	0.00	3.5	2.4
Metal Proc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0
Petrol Ind	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.2	0.1
Other Ind	0.02	0.16	0.00	0.09	1.32	0.00	0.08	0.00	1.7	1.2
Solvent	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.0	0.0
Waste Disp	0.04	0.07	0.03	0.04	0.16	0.02	0.06	0.07	0.5	0.3
On Road	2.37	2.21	0.73	2.45	11.97	0.64	7.58	9.15	37.1	25.7
Off Road	1.85	2.78	0.74	1.03	7.06	0.74	5.34	2.35	21.9	15.1
Misc.	0.01	0.03	0.03	0.01	0.01	0.01	0.08	0.00	0.2	0.1
	6.08	42.27	1.84	4.09	60.24	1.47	14.28	14.34	144.6	100.0





2007 NOx Emissions in Kingsport EAC (145 tpd)
15.1%
22.3%
25.7%
30.4%
0.3%
1.2%
2.4%
2.3%
Elec Util
Ind comb
Other comb
Chem Prod
Metal Proc
Petrol Ind
Other Ind
Solvent
Waste Disp
On Road
Off Road
Misc.



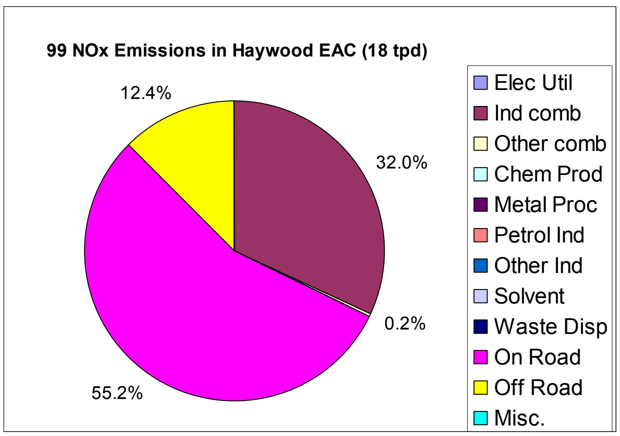
Johnson City, Kingsport, Bristol EAC Area
2007 Emissions Contribution by Each Vehicle Type
Percent of Total Emissions
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
LDGV
LDGT12
LDGT34
HDGV
MC
LDDV
LDDT
HDDV
Vehicle Category
VOC
NOx
CO

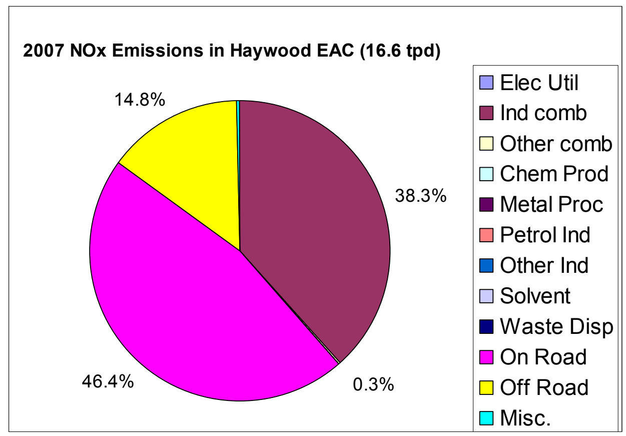
1999 Haywood EAC Emissions (tons/day)

	Haywood	%
Elec Util	0.00	0.0
Ind comb	5.76	32.0
Other comb	0.04	0.2
Chem Prod	0.00	0.0
Metal Proc	0.00	0.0
Petrol Ind	0.00	0.0
Other Ind	0.00	0.0
Solvent	0.00	0.0
Waste Disp	0.01	0.1
On Road	9.91	55.2
Off Road	2.22	12.4
Misc.	0.02	0.1
	17.96	100.0

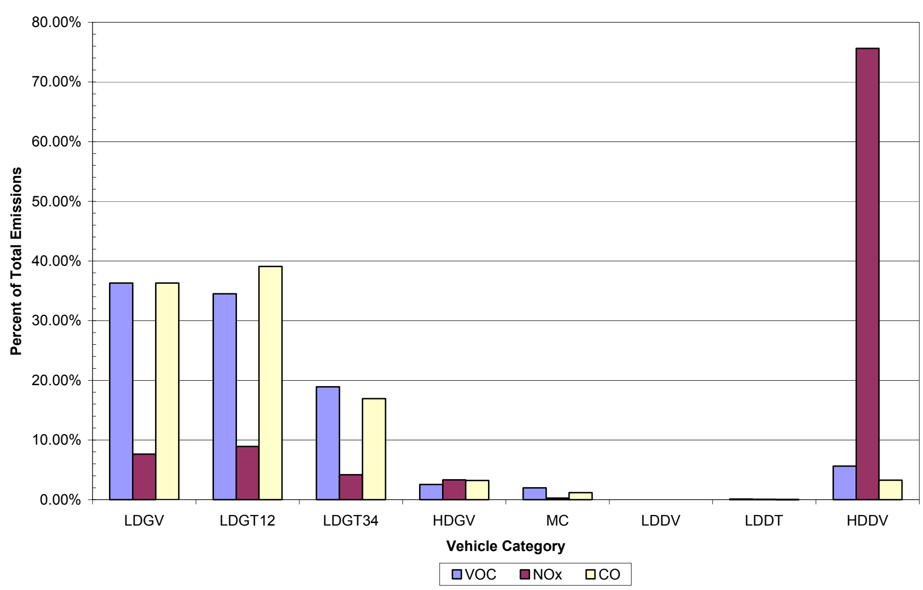
2007 Haywood EAC Emissions (tons/day)

	Haywood	%
Elec Util	0.00	0.0
Ind comb	6.36	38.3
Other comb	0.04	0.3
Chem Prod	0.00	0.0
Metal Proc	0.00	0.0
Petrol Ind	0.00	0.0
Other Ind	0.00	0.0
Solvent	0.00	0.0
Waste Disp	0.02	0.1
On Road	7.70	46.4
Off Road	2.46	14.8
Misc.	0.02	0.1
	16.60	100.0





Haywood County/EAC
2007 Emissions Contribution by Each Vehicle Type



VOC and NOx Emissions in Tons/day for 2007 for Each EAC

EAC	Manmade VOCs	Total VOCs	Manmade NOx (Atmos Advisor)	Manmade NOx (EPA/UT)
Knoxville EAC	158	598	137	158
Nashville EAC	232	780	290	298
Memphis EAC	223	618	232	283
Kingsport EAC	94	358	128	127
Chattanooga EAC	146	1073	145	92
Lawrence Co	15	173	5	not reported
Putnam Co EAC	21	95	19	not reported
Haywood Co	8	105	17	16

2.2. Preliminary Ozone Modeling Results

This section provides a preliminary analysis of ozone modeling results that have been completed by the ATMOS modeling group for the 1999 Basecase and for the 2007 Baseline. The 2007 baseline modeling included the following assumptions with respect to emission inventories, as provided by the modeling group:

Area Sources

* Applied BEA GSP projection factors to base case emissions (1996 area source emissions provided by MDEQ; 1999 area source emissions provided by Davidson and Hamilton counties, TN; NET96V3 data for other states and counties)
* Applied energy adjustment factors for fuel combustion sources
* VOC area source controls included Federal control measures, Title III MACT and Title I RACT assumptions
* Additional controls were applied for residential wood combustion and Stage II VOC for gasoline service stations, where applicable
* Incorporated 2007 area source emission estimates for the State of Texas
* Eliminated all emissions due to a seasonal ban on open burning in the 13-county Atlanta nonattainment area and additional 32 counties in Northern Georgia

Point Sources

* Applied BEA GSP projection factors to base case emissions (1999 point source emissions provided by Hamilton, Davidson and Knox counties, TN; 1998 point source emissions provided by Shelby county, TN; 1999 point source emissions provided by ADEM and MDEQ; NET96V3 data for other states)
* Applied energy adjustment factors for the non-EGU fuel combustion sources
* NOx SIP Call controls applied to the EGU and non-EGU sources located in the SIP Call-affected States
* Non-EGU point source controls included CAA baseline control assumptions and MACT assumptions
* Incorporated 2007 emission estimates for TVA
* Day-specific 2007 emission estimates from Southern Company for WFOS September 1997 episode were incorporated in the inventory with the day of week matches
* Incorporated 2007 point source estimates for State of Texas
* Incorporated 2007 emission estimates for Eastman Chemical Company in Tennessee

Non-Road Mobile Sources

* Used EPA NONROAD2002 model
* Applied BEA GSP projection factors for emissions from aircraft, railroad and commercial marine vessels (NET96V3 data)

On-Road Mobile Sources

* Used MOBILE6 with state provided 2007 VMT data and September temperatures for states of Alabama, Arkansas, Georgia, South Carolina and Tennessee
* Used MOBILE6 with 2007 FHWA VMT data and seasonal temperatures for all other states

Biogenic Sources

* BEIS 2 with new 4-km landuse data (same as base case)

A preliminary analysis has been conducted of the 1999 basecase and the 2007 baseline results that were completed on April 2, 2003. This analysis included a comparison of the 1999 Design value for each monitoring station in each EAC with the Estimated Design Value predicted in the 2007 baseline modeling. The design value for 1999 is the 8-hr ozone value which represents the three year average of the 4th highest 8-hr ozone concentration observed at each monitoring site based on the 1997-1999 ozone seasons. That design value would have to be less than 85 ppb for an area to be in attainment for the 8-hr standard. The modeling exercise predicts the estimated design value for 2007 for each monitor. Thus, one criterion or metric used in accessing whether a future year meets the standard is to determine if the future year estimated design value is below 85 ppb. If not, then additional reductions beyond those used in the baseline modeling would likely be required. Table 2.2.1 shows a comparison of the 1999 Design Value for each monitor, grouped by EAC, with the estimated 2007 Design Value. The Chattanooga

EAC monitors, the Kingsport EAC monitors, the Haywood EAC monitor, the Lawrence County monitor, and the Putnam EAC monitor show estimated design values that are less than 85 ppb for the 9 grid cell area surrounding the monitors-- an indication that at least the area within the vicinity of the monitors may meet the standard by 2007. However, the estimated design values for the other EACs indicate that some monitors within each EAC are predicted to be above the standard without additional strategies being implemented.

The fourth column in the table (Red.O3DV,%) shows the percent reduction in the estimated design value at each monitor when compared to the 1999 design value. The bold value at the end of each EAC's column provides the average reduction in the design value providing an indication of the relative decrease in ozone associated with the emission reductions that are predicted to occur between 1999 and 2007. For those areas that did not meet the 85 ppb design value, additional calculations were made. The fifth column (Red.NOx,%) provides an estimation of the reduction in NOx emissions that will occur in the EAC between 1999 and 2007. These estimates are based on the total NOx emission values in tons/day that are shown for each EAC in Section 2.1. The sixth column (RedVOC,%) provides an estimate, based on the inventory used in the ATMOS modeling, of the VOC reductions that are predicted to occur between 1999 and 2007. Using the Knoxville EAC as an example, the Knoxville EAC is estimated to have 218 tons/day of NOx emissions in 1999 and 158 tons/day in 2007, or a reduction of 27.5%. The VOC reduction was estimated to be 12%. A comparison of Column 4 to column 5 and 6 for the Knoxville EAC shows that a 9.0% reduction in ozone was achieved on the average as a result of a 27.5% reduction in NOx emissions and a 12% reduction in VOCs. This analysis assumes that the effect of ozone reduction is primarily a result of a reduction in local emissions, which may not be altogether true, given the regional nature of emissions and ozone formation. Yet, very similar results are shown for the other EACs. The final column in Table 2.2.1 (column seven) shows the additional ozone reduction needed in percent to achieve the 85 ppb design value at each monitor in 2007. The required reduction in ozone concentration varies from zero up to 12.0% depending on the EAC and monitor. It is apparent from the modeling results and the data in columns four, five and six, that a percentage reduction in ozone requires a substantially greater reduction in NOx or VOCs, with the ratios varying from one to one up to one to three. The analysis is complicated by the fact that both NOx and VOCs are reduced. In general, the Tennessee region is NOx limited, indicating that it is not as sensitive to VOC reductions as it is to NOx reductions. However, the effect is complex and this may not hold in the highly urbanized center city areas.

The above analysis provides some insight into the reductions in NOx and VOCs that might be required for an area to meet the standard. However, the discussion herein only addresses the issue of the predicted design value in the vicinity of the monitors. Further analyses will be needed to address other metrics such as whether there are hot-spots of ozone that are predicted by the model within the modeling domain that do not occur at the monitoring sites. These analyses are on going by the modeling group.

Table 2.2.1. Summary of Preliminary 2007 Modeling Results for Each EAC

Monitoring Station	99 DV	07 EDV	Red. DV, %	Red. NOx, %	Red. VOC, %	Red. O3, %
Knoxville EAC						
Look Rock	104	95.7	8.0			11.2
Anderson	88	79.8	9.3			0
Cades Cove	83	74.9	9.8			0
Clingmans Dome	98	90.0	8.2			5.6
Cove Mountain	99	89.9	9.2			5.5
East Knox	102	92.8	9.0			8.4
Spring Hill	100	92.3	7.7			7.9
Jefferson County	103	93.8	8.9			9.4
Oak Ridge	93	83.2	10.5			0.0
AVG:			**9.0**	**27.5**	**12**	
Kingsport EAC						
Kingsport	91	68.3	24.9			0
Sullivan	88	78.4	10.9			0
AVG:			**17.9**	**15.2**	**48**	
Chattanooga EAC						
Sequoyah	94	83.7	11.0			0
Chatt VAAP	94	84.1	10.5			0
AVG:			**10.7**	**19.3**	**18.5**	
Nashville EAC						
Percy Priest	90	82.9	7.9			0
Rutherford	90	81.9	9.0			0
Dickson	101	92.7	8.2			8.3
East Nashville	91	83.2	8.6			0
Lebanon	87	78.8	9.4			0
Rockland	102	96.6	5.3			12.0
C.Wrights Farm	91	83.1	8.7			0.0
Fairview	95	85.9	9.6			1.0
AVG:			**8.3**	**15.3**	**15**	
Memphis EAC						
Frayser	95	88.6	6.7			4.1
DeSota MS	88	77.3	12.2			0
Edmon Orgill	95	85.9	9.6			1.0
Marion Arkansas	90	85.9	4.6			1.0
AVG:			**8.3**	**18.2**	**16**	
Haywood EAC	93	81.7	12.2			0
Lawrence	88	76.6	13.0			0
Putnam EAC	88	79.8	9.3			0

2.3 Emission Reduction Strategies and Costs

Twenty-five different air pollution control strategies have been investigated for the purpose of identifying potential emission reduction actions that can be taken to reduce air pollution emissions sufficiently in Tennessee Early Action Compact areas to obtain the 8-hour average National Ambient Air Quality Standard for ozone. Most of the strategies and results presented herein focus on nitrogen oxide (NOx) emission reduction actions, on the assumption that NOx emission reductions will do more toward attaining the ozone standard than VOC or CO reductions.

Separate sections of Chapter 3 describe each emissions reduction action in detail, the amount of emission reductions potentially achievable, and the cost of obtaining the reduction in dollars per ton. The results for the 25 strategies evaluated are summarized in Tables 3.2.1 and 3.2.2. Table 3.2.1 presents the tons/day emission reduction potentially achievable and the percent reduction in area-wide emissions this represents within a base-case area. The base-case area is usually the Knoxville EAC that is projected to have 158 tons/day of NOx and 598 tons/day of VOC emissions (including biogenic emissions) in 2007. Anthropogenic VOC emissions for the Knoxville EAC are 158 tons/day.

For some strategies, calculations were not done for the Knoxville EAC. Instead emission estimates from published reports for other areas such as Los Angeles and Atlanta were used to estimate the potential emission reductions. The appendix of this report contains three additional tables that summarize potential emission reductions for NOx by various strategies. One table summarizes 24 CMAQ (congestion mitigation for air quality) projects in US cities; one table summarizes various control measures proposed for the Atlanta area; and one table summarizes some of the proposed control measures for Los Angeles.

Emission reduction strategies highlighted in Table 2.3.1 covers point source, non-road mobile source, and on-road mobile source emission reductions. Some of the largest potential reductions are for point sources. Of the mobile source strategies, inspection and maintenance programs, diesel fuel additives, truck electrification, and lowering the speed limit on rural interstates produce the greatest potential emission reductions. Transportation Control Measures (TCMs) such as those listed as actions 14 –23 show much less potential for reducing NOx. This is consistent with the conclusions of the San Francisco Bay Area MTC that concluded “TCMs achieve very modest emission reductions when compared to the cuts needed to reach federal standards”. Excluding transportation pricing reform, which requires legislative authorization, TCMs save only one or two tons of NOx and VOC emissions per day in the Bay Area. (A copy of a table summarizing potential emission reductions from TCMs in the Bay Area is included in the appendix.)

Table 2.3.2 summarizes the costs in $/ton of emission reduction. Details of how the costs were calculated for each strategy are included in Sections 3.1 to 3.24. The lowest cost strategy for reducing NOx emissions is $1200 per ton. Many strategies cost tens of thousands of dollars per ton of NOx reduced. Several of the most expensive strategies evaluated were more than $100,000 per ton.

Tables 3.2.1 and 3.2.2. can be used by MPO's and others to select emission reduction strategies for further consideration that may help attain the ozone NAAQS in Early Action Compact areas. Most of the data summarized in the tables concerns only the reduction of NOx, however it should be noted that many of the emission control strategies also reduce VOC, and CO emissions as well as particulate matter emissions in some cases, all of which may have a beneficial impact on air quality. When choosing emission reduction strategies, EPA guidance limits the total emission reduction credit allowed for voluntary programs to 3% of the total emission reduction needed to attain air quality standards. Those programs that EPA considers to be voluntary can be identified by the notation, (VOL) included the tables.

Table 2.3.1 Estimates of NOx Emission Reductions Potentially Achievable in Tennessee Ozone Early Action Compact (EAC) Areas

Second Draft - Prepared by UT-CEE (4/14/03)

Emission Reduction Actions	Area-wide Potential Reduction (Tons/Day)	(Percent)	Basis
1. Inspection and Maintenance Programs (Stringent program)	5.9 NOx 10.7 VOC	3.6% (2007) 6.8%	Knox EAC MOBILE6
2. Additional Controls (SCR) on Electrical Utility Sources (e.g. TVA's John Sevier, Gallatin, & Johnsonville Steam Plts)	95	6.6%	Statewide
3. Additional Controls on 30 Industrial Sources w >500 tpy NOx (e.g. VOC controls and low NOx fuels & combustors)	39.7 11.4	2.8% 2%	Statewide GSU
4. Alternative Fuels on New Buses (e.g. CNG & LNG yield 50% reductions in NOx. Ethanol, propane, and biodiesel yield less reduction.)	0.065/100 LNG Buses NOx 50% less VOC/LNG Bus	0.04%	Knox EAC EPA Fact Sheets
5. Replacing Old Diesel HDVs with Low Emission HDVs or ZEVs (e.g. ULEV & ZEV buses and fleets; tax exemptions for private fleets; Permits and Air Quality Plan requirements of fleet owners)	0.21/100 Buses NOx 0.044/100 School Buses 0.016/100 HDGV2bs 0.0029/100 cars	0.13% 0.03% 0.01% 0.002%	MOBILE6 Knox EAC
6. Lower Speed Limit on Trucks Only (HDVs) (i.e. from 70 to 55 mph on rural interstates)	5.82 NOx VOCs increase 0.04%	3.7%	Knox EAC MOBILE6
7. Lower Speed Limit on Cars & Trucks (i.e. from 70 to 55 mph on rural interstates)	5.96 NOx VOCs increase 0.55%	3.76%	Knox EAC MOBILE6
8. Diesel Fuel Additives (3% less NOx w Cetane) On & Off-road	2.0 NOx	1.3%	Knox EAC

Emission Reduction Actions	Area-wide Potential Reduction (Tons/Day)	(Percent)	Basis
9. Stage II Vapor Recovery at Gasoline Stations	0 NOx 6.2 VOC	0 3.9%	Knox EAC
10. Off-Road Mobile Sources, accelerate replacement of old equipment, fuel switch, or retrofit with catalytic converters and particulate traps. Applies to compressors, dozers, graders, dump trucks, etc.	9 (2006) 19 (2015)	1% 2.1%	Los Angeles Los Angeles
11. Lawnmower Rebate/Buy Back Program (VOL). Could also apply to other small gasoline engine equipment.	0.0012/500 mowers 0.9	0.0007% 0.1%	Knox EAC Los Angeles
12. Transportation Planning & Land Use Restrictions Designed to Hold the VMT Growth Rate to the Population Growth Rate (e.g. pay-as-you-drive insurance)	0.18% Less NOx per 1% Reduction in VMT		
13. Legislate California LEV II Standards for SULEV/ZEVs (voluntary programs achieve less emission reduction)	0.37 NOx 0.40 VOC	0.2%	CA LEV II Standards
The Following Actions are Transportations Control Measures (TCM's) As Defined by the Clean Air Act –			
14. Improve Transit (low emission buses and divert trips to transit)	0.12 NOx	0.08%	Knox EAC
15. Build High Occupancy Vehicle (HOV) Lanes	0.20 NOx 0.29 VOC	0.13% 0.18%	Knox EAC
16. Traffic Flow Improvement Programs (e.g. traffic signal synchronization)	0.43 NOx 0.044 NOx	0.07% 0.03%	AtlantaCMAQ Knox EAC

Emission Reduction Actions	Area-wide Potential Reduction (Tons/Day)	(Percent)	Basis
17. Area-wide Rideshare Incentives (VOL)	0.28 per 1% Reduction in VMT	0.1%	Knox EAC
18. Parking Management with Preference to Car/Vanpools (VOL)	0.039 NOx per 1000 vanpool only spaces	0.02%	
	0.054 VOC per 1000 vanpool only spaces	0.03%	
19. Work Schedule Changes to Reduce Peak Demands (VOL) (Also restrictions on certain activities like construction/road-building).	0.004 NOx per 1000 4-day work-week participants		
20. Employer-based Transportation Management Plans (VOL)	0.013 NOx per 1000 participants	0.008%	Knox
	0.018 VOC per 1000 participants	0.011%	EAC
21. Bike Trails and Bike Racks at Work Sites (VOL)	0.018 NOx		Philadelphia
	0.010 NOx/1000 bicyclers	0.006%	Knox EAC
22. Pedestrian Greenways (VOL)	0.002 NOx/1000 walkers	0.001%	
23. Truck Stop Electrification (VOL) to reduce idling HDDV	2.1 NOx	0.2%	Los Angeles
(Programs can also address other excess idling.)	0.82 NOx/1000 truck spaces	0.5%	Knox EAC
24. Programs to Encourage Removal of Pre-1980 Vehicles & Super-emitters	0.03 per 1000 vehicles		EPA Doc
(e.g. remote sensing and scrappage programs, test impounded vehicles,	0.017 NOx per 1000 vehs	0.011%	Knox EAC
deny registration to repeated I/M failures, enforce smoking vehicles,	0.388 CO per 1000 vehs		
fund program with a license plate fee). (VOL)	0.019 VOC per 1000 vehs	0.012%	Knox EAC
25. Land Use Programs to Enhance Emission Reductions (e.g. roof color restrictions, landscaping without lawn-mowing, encourage trees)	NA	NA	NA

Table Footnotes:
Voluntary Actions are labeled (VOL): Emission credits from voluntary actions are limited to 3 percent of the emission reductions needed to achieve the NAAQS.
Abbreviations Used to Describe the Basis for the emission reduction estimates:
MOBILE6 = EPA's MOBILE6 emissions model.
LNB = Low NOx Burners with 37% NOx reduction.
SCR = Selective Catalytic Reduction with 75% NOx reduction.
GSU = Georgia State University study of emission reductions possible in the 13-County Atlanta Non-attainment Area
EPA Fact Sheets = EPA Fact Sheets on Alternative Fuels at: www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm#fact
Footnotes Continued:

Knox EAC = Knoxville EAC 9-county area with 158 tons/day NOx & VOC (anthrogenic) & 598 tons/day biogenic VOC.
Davidson Co. = Davidson County (only) with 54 tons/day of on-road mobile NOx emissions.
VOC Only = Stage II controls effect only volatile organic compound emissions, not NOx.
Los Angeles = Data taken from the South Coast Air Quality Management Districts Draft 2003 Air Quality Management Plan (www.aqmd.gov/aqmp/#03aqmp)
CMAQ = Taken from the USEPA Report "*Summary Review of Costs and Emissions Information for 24 Congestion Mitigation and Air Quality Improvement Program Projects" available at www.epa.gov/otaq/transp/traqmodl.htm*
EPA Doc = Data taken from EPA Document "*Guidance for the Implementation of Accelerated Retirement of Vehicles Programs*" – EPA420-R-93-018.

Table 2.3.2 Estimates of the Cost of NOx Emission Reductions in Tennessee Ozone Early Action Compact (EAC) Areas
Second Draft - Prepared by UT-CEE (4/14/03)

Emission Reduction Actions	Cost Per Ton NOx ($/Ton)	Other Considerations
1. Inspection and Maintenance Programs (Stringent program)	31,000	$20/test, $145/repair
2. Additional Controls on Electrical Utility Sources (e.g. TVA's John Sevier Steam Plant)	2,000	SCR
3. Additional Controls on Industrial Sources (e.g. VOC controls and low NOx fuels & combustors)	1,200 to 8,000	GSU LNB
4. Alternative Fuels on New Buses (e.g. CNG & LNG yield 50% reductions in NOx. Ethanol, propane, and biodiesel yield less reduction.)	19,000 for LNG Buses	$40,000/bus extra cost
5. Replacing Old Diesel HDVs with Low Emission HDVs or ZEVs (e.g. ULEV & ZEV buses and fleets; tax exemptions for private fleets; Permits and Air Quality Plan requirements of fleet owners)	19,000 for LNG Buses	$40,000/bus extra cost
6. Lower Speed Limit on Trucks Only (HDVs) (i.e. from 70 to 55 mph on rural interstates)	NA	Cost is Mostly Lost Time
7. Lower Speed Limit on Cars & Trucks (i.e. from 70 to 55 mph on rural interstates)	NA	Cost is Mostly Lost Time
8. Diesel Fuel Additives (3% less NOx w Cetane)	4,100	$.01/gal to fuel

Emission Reduction Actions	Cost Per Ton NOx ($/Ton)	Other Considerations
9. Stage II Vapor Recovery at Gasoline Stations	1,200 per ton of VOCs	No NOx Control
10. Off-Road Mobile Sources, accelerate replacement of old equipment, fuel switch, or retrofit with catalytic converters and particulate traps. Applies to compressors, dozers, graders, dump trucks, etc.	4,000 to 13,000	Engine Replacements
11. Lawnmower Rebate/Buy Back Program (VOL). Could also apply to other small gasoline engine equipment.	13,000	Rebate of $60/mower
12. Transportation Planning & Land Use Restrictions Designed to Hold the VMT Growth Rate to the Population Growth Rate (e.g. pay-as-you-drive insurance)	NA	
13. Legislate California LEV II Standards for SULEV/ZEVs (voluntary programs achieve less emission reduction)	690,000 NOx, 14,000 CO 530,000 VOC	$6000/car extra cost
The Following Actions are Transportations Control Measures (TCM's) As Defined by the Clean Air Act –		
14. Improve Transit (low emission buses and divert trips to transit)	14,000 to 425,000	CMAQ
15. Build High Occupancy Vehicle (HOV) Lanes	19,000 NOx 13,000 VOC	Road Cost $1 mil/mile
16. Traffic Flow Improvement Programs (e.g. traffic signal synchronization)	102,000	CMAQ

Emission Reduction Actions	Cost Per Ton NOx ($/Ton)	Other Considerations
17. Area-wide Rideshare Incentives (VOL)	16,000 to 158,000	CMAQ
18. Parking Management with Preference to Car/Vanpools (VOL)	3500 NOx 2500 VOC	Incl Govn Cost Only
19. Work Schedule Changes to Reduce Peak Demands (VOL) (Also restrictions on certain activities like construction/road-building).	1,000,000	Incl Govn Cost Only
20. Employer-based Transportation Management Plans (VOL)	230,000 NOx 167,000 VOC	Subsidy $.30/mile
21. Bike Trails and Bike Racks at Work Sites (VOL)	46,500	Philadelphia CMAQ
22. Pedestrian Greenways (VOL)	46,500	Philadelphia
23. Truck Stop Electrification (VOL) to reduce idling HDDV (Programs can also address other excess idling.)	1,660	Idle-Air Knoxville
24. Programs to Encourage Removal of Pre-1980 Vehicles & Super-emitters (e.g. remote sensing and scrappage programs, test impounded vehicles, deny registration to repeated I/M failures, enforce smoking vehicles, fund program with a license plate fee). (VOL)	59,000 NOx 66,250 VOC 2,950 CO	Subsidy $1000/veh

Table Footnotes:
Voluntary Actions are labeled (VOL): Emission credits from voluntary actions are limited to 3 percent of the emission reductions needed to achieve the NAAQS.
Abbreviations Used to Describe the Basis for the emission reduction estimates:
MOBILE6 = EPA's MOBILE6 emissions model.
LNB = Low NOx Burners with 37% NOx reduction.
SCR = Selective Catalytic Reduction with 75% NOx reduction.
GSU = Georgia State University study of emission reductions possible in the 13-County Atlanta Non-attainment Area
EPA Fact Sheets = EPA Fact Sheets on Alternative Fuels at: www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm#fact
Footnotes Continued:

Knox EAC = Knoxville EAC multi-county area with 158 tons NOx emissions per day.
Davidson Co. = Davidson County (only) with 54 tons/day of on-road mobile NOx emissions.
VOC Only = Stage II controls effect only volatile organic compound emissions, not NOx.
Los Angeles = Data taken from the South Coast Air Quality Management Districts Draft 2003 Air Quality Management Plan (www.aqmd.gov/aqmp/#03aqmp)
CMAQ = Taken from the USEPA Report "*Summary Review of Costs and Emissions Information for 24 Congestion Mitigation and Air Quality Improvement Program Projects" available at www.epa.gov/otaq/transp/traqmodl.htm*
EPA Doc = Data taken from EPA Document "*Guidance for the Implementation of Accelerated Retirement of Vehicles Programs*" – EPA420-R-93-018.

3.0 Detailed Calculations

3.1 Effect of a Stringent I/M Program on On-Road Mobile Source Emissions

3.1.1. Introduction

As part of the Ozone Early Action Compact (EAC) program, the participating agencies need to identify potential emission reduction actions that might be used to meet the emissions budget for the year 2007. For the on-road mobile source sector, one of the options proposed is the enforcement of a stringent vehicle inspection and maintenance (I/M) program in the EAC areas. This section summarizes a possible combination of inspection programs that might be considered as a "stringent" I/M Program, the emission reductions that might be achieved in the year 2007 and the associated cost analysis.

3.1.2. Current I/M Program in Tennessee and its implications

Only six counties in Tennessee currently have an I/M program in place. They include Davidson, Rutherford, Sumner, Williamson, Wilson and Shelby counties. Although specific parameters of the I/M program may differ between these counties to a certain extent, the basic type of inspection that is conducted at all these locations is an idle test. Based on calculations done by the University of Tennessee (Davis et al., 2002), it is shown that the implementation of an I/M program similar to that in place at Davidson County, would yield about a 6% reduction in NO_x emissions and a 22% reduction in VOC emissions in the year 2007, compared to a situation without an I/M program in place.

3.1.3. Proposed "Stringent" I/M Program

The on-road emission factor model, MOBILE6.2, was used to identify the emissions reductions associated with an I/M program. A series of MOBILE6.2 runs were done in an effort to determine the best option of a combination of evaporative and exhaust inspections that might be considered "stringent". All the MOBILE6.2 model runs were done for the analysis years 2007 and 2030. A base-case run represented a scenario with no I/M program in place and a fuel RVP of 9.0psi. The combination of I/M tests that is proposed will be referred to as the "stringent I/M" in further discussions in this report. Most of the parameters were set to national default values in the MOBILE6.2 model. For those parameters that required a mandatory input, Table 3.1.1 lists the input parameters that were used in the model runs.

The proposed stringent I/M program consists of a combination of the exhaust and evaporative inspections. It is assumed that these programs would begin in the year 2004 and would be a "test-only" program. The exhaust I/M program consists of an enhanced I/M program, namely the IM240, applied to all gasoline vehicles for model years older than 1996. The cutpoints that determine whether a vehicle has passed or failed the IM240 test are shown in Table 3.1.1. Since the on-board diagnostics (OBD) were supposed to be on all light duty gasoline vehicles and trucks for model years 1996 and newer, and on all heavy-duty gasoline vehicles for model years 2007 and newer, those vehicles that are 1996 and newer would be subjected to an OBD I/M program. Since OBD would be present in HDGV only after 2006, the HDGV would be subjected to IM240 program for model years 1996 -2006. In this stringent I/M program, the 1996 and newer vehicles for LDGV and LDGT, and 2007 and newer for HDGV, are not subject to IM240, because it is hoped that the OBD inspection would "catch" any problem with the vehicle and would be a more simplistic and an efficient way of inspection. The evaporative I/M program consists of a fill-pipe pressure (FP) test, gas cap (GC) inspection and an evaporative OBD check. The FP and GC tests would be applied to all gasoline vehicles for model years prior to 1996. LDGV and LDGT of model years 1996 and later, and HDGV of model years 2007 and later would be subjected to OBD and GC tests. Due to the limitation of the maximum number of I/M programs that can be modeled consecutively in MOBILE6.2, the effect of GC inspections on HDGV of model years 1996-2006 could not be modeled. However, it is felt that this effect would be negligible on VOC emissions, and none on CO and NO_x emissions, and hence would not be a major concern for evaluation purposes.

Table 3.1.1. Input Parameters used in MOBILE6.2 model runs

Parameter	**Value**
Analysis Year	2007, 2030
Min/Max Temperature (deg F)	60/93
Evaluation Month	7
Fuel RVP (psi)	9.0 (without I/M – base case) and 7.8 (with I/M)
Vehicles subject to I/M Program	All gasoline Vehicles – LDGV, LDGT1234, HDGV, HDGB
I/M Stringency for pre-1981 model years	50%
I/M Compliance	100%
Exemption Age	25 years (MOBILE6 default)
Grace Period	1 year (MOBILE6 default)
Cut Points for IM240 inspection (g/mi)	HC:0.8, CO:15, NO_x:2
I/M Waiver Rates	2 different scenarios: 0% waiver and 5% waiver for both, pre and post 1981 model years.
Davidson County I/M Program	Idle Test for model years until 1995 and exhaust OBD test since 2002, for model years 1996 and later. Evaporative OBD and GC since 2002. Stringency of 30%, Compliance of 98% and waiver rate of 0%. Applied to LDGV and LDGT1234.

3.1.4. Implications of Stringent I/M Program

Emissions Reduction: The MOBILE6.2 model lists the emission factors in terms of grams of pollutant per vehicle mile traveled. The model results are shown in Table 3.1.2. The results clearly indicate that the implementation of the proposed stringent I/M program would provide a maximum reduction of about 8.3% in NO_x and about 25.8% in VOC emissions, relative to a situation with no I/M. This estimated emissions reduction is more pronounced in the future. As shown in the table, in the year 2030, the emissions reduction would be about 42.4% in NO_x and about 37.2% in VOC emissions, relative to a situation with no I/M.

Emissions calculations conducted for Davidson County (Davis et al., 2002) provide an overview of the nature of reductions that might be expected over the next 30 years. Figures 3.1.1 and 3.1.2 illustrate this concept. It is evident that the emissions from on-road mobile sources continue to decrease until about 2025. It is also clear that, although the emissions reduction from implementation of the I/M is only about 6% in NO_x and about 22% in VOC in the year 2007, the emissions reduction estimated to be achieved by the year 2030 is far greater (42% in NO_x and 39% in VOC) as shown in Table 3.1.2. The emissions reduction shown for Davidson County (with a relatively "not-so-stringent" I/M) is slightly greater than that observed with the proposed stringent I/M. This difference could be due to differences in parameters such as the vehicle age mix and the VMT mix for Davidson County, compared to the national defaults used in the current model runs.

It is evident from Table 3.1.2(b) that the emissions reduction achieved from the proposed stringent I/M program is not significantly greater than that obtained through the basic I/M program (idle test and OBD) in Davidson County, realizing that differences in input parameters do exist. Discussions with personnel at the I/M testing stations also indicate that the basic I/M program may produce results as good as the enhanced I/M (IM240) program, based on their experience with emissions testing at different locations in the US. Hence, an IM240 program may not necessarily produce much more emission reduction than that seen with a basic I/M program.

Cost Analysis: A simple cost analysis was done to evaluate the cost involved per ton of pollutant reduction. Supporting information for cost analysis was obtained from the article by Harrington et al. (1999). The article described the enhanced I/M program in Arizona and provided information on the failure rate and the costs associated with testing and repair, which were used as starting values for the cost analysis in this section. Table 3.1.3 shows the failure rate and the repair costs recorded in the IM240 program in Arizona. (Harrington et al., 1999).

Since the reported costs and inspection failure rates varied by model year, a weighted mean repair cost ($123) and a weighted mean stringency (26%) was calculated as shown in the table. The inspection cost in Arizona during 1995-1996 was $16.75. These costs were adjusted to a 2002 dollar value based on the conversion factors reported by Robert Sahr (2003). On conversion, the inspection cost and the mean repair cost evaluated to

$19.21 and $141.08 respectively. This calculation used an inspection cost of $20 per vehicle and a mean repair cost of $145. The mean repair cost when multiplied by the failure rate (number of vehicles that failed the test/total number of vehicles that went through the test) resulted in the repair cost per vehicle tested. Based on these values, the total cost per vehicle tested is $57.70. These are tabulated in Table 3.1.4.

Table 3.1.2. Model Results and Emission Reduction Summary

(a) Emission Factor

Scenario	**Waiver Rate**	**Emission Factor in grams/mile**					
		NO_x		**VOC**		**CO**	
		2007	**2030**	**2007**	**2030**	**2007**	**2030**
Base Case	Not applicable	1.743	0.347	1.244	0.443	12.779	7.720
Stringent I/M	0% waiver	1.598	0.200	0.923	0.278	9.388	5.121
Stringent I/M	5% waiver	1.602	0.206	0.929	0.282	9.480	5.204

(b). Percent Reductions and Ton/Day Reduction Per Million DVMT

Scenario	**Waiver Rate**	**% Reduction Relative to Base Case and Ton/Day Reduction per Million VMT in brackets**					
		NO_x		**VOC**		**CO**	
		2007	**2030**	**2007**	**2030**	**2007**	**2030**
Stringent I/M	0% waiver	8.3% (0.16)	42.4% (0.16)	25.8% (0.35)	37.2% (0.18)	26.5% (3.74)	33.7% (2.87)
Stringent I/M	5% waiver	8.1% (0.16)	40.6% (0.16)	25.3% (0.35)	36.3% (0.18)	25.8% (3.64)	32.6% (2.77)
Davidson County I/M	0% waiver	6.2% (0.13)	41.6% (0.15)	21.7% (0.22)	39.1% (0.15)	23.2% (2.91)	33.5% (2.65)

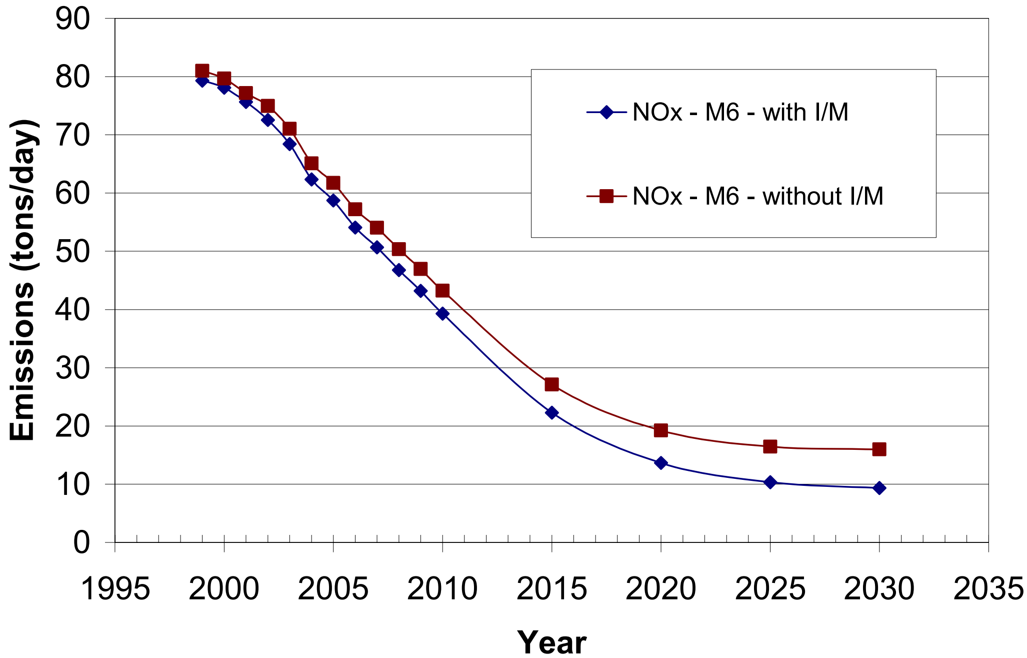


Figure 3.1.1. Davidson County - NO_x Emissions with and without I/M Program

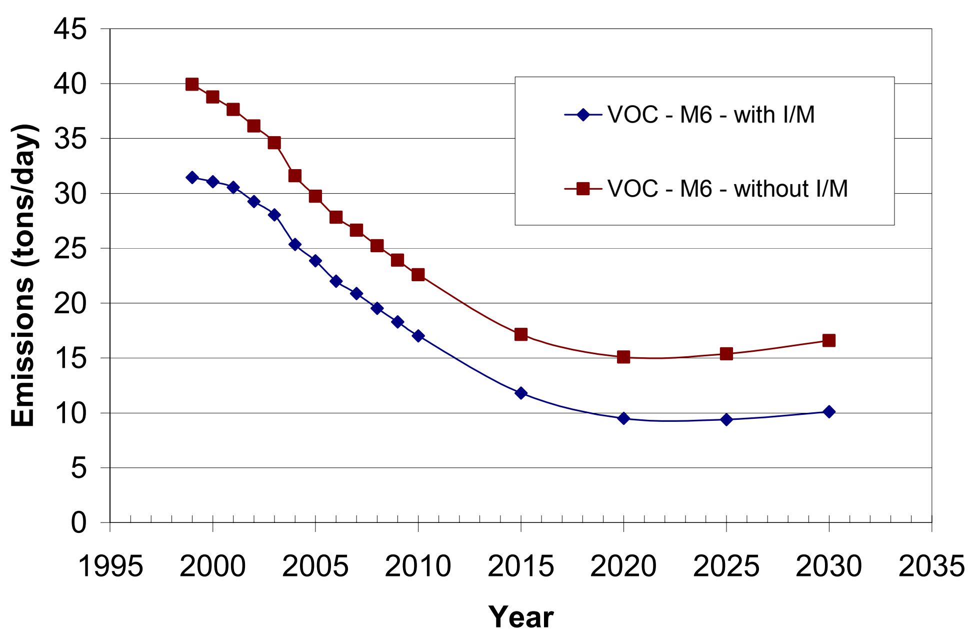


Figure 3.1.2. Davidson County - VOC Emissions with and without I/M Program

Table 3.1.3. Failure Rates and Mean Repair Costs in Arizona's IM240 Program

	Model Year	Number of Vehicles	Mean Repair Costs*	Failure Rate	No. Veh * Mean Repair Cost	No. Veh * Failure Rate
Cars	81-82	10,320	123	50	1,269,360	516,000
	83-85	24,067	135	38	3,249,045	914,546
	86-88	14,696	128	17	1,881,088	249,832
	89-90	4,121	120	7	494,520	28,847
	91-92	3,254	128	5	416,512	16,270
	93-95	1,101	72	1	79,272	1,101
Trucks less than 6000 lbs	81-82	2,458	67	26	164,686	63,908
	83-85	4,855	113	26	548,615	126,230
	86-88	3,442	100	15	344,200	51,630
	89-90	4,691	129	10	605,139	46,910
	91-92	2,061	124	8	255,564	16,488
	93-95	1,184	114	2	134,976	2,368
Trucks greater than 6000 lbs	81-82	1,252	77	40	96,404	50,080
	83-85	1,863	121	33	225,423	61,479
	86-88	1,422	120	21	170,640	29,862
	89-90	1,106	113	9	124,978	9,954
	91-92	568	122	10	69,296	5,680
	93-95	325	76	3	24,700	975
Sum =		82,786			10,154,418	2,192,160
					Weighted Mean Repair Cost =	*Weighted Mean Stringency (%)=*
Weighted Average =					$123	26

* Mean Repair Costs include actual reported costs plus estimated costs when repairs were done but zero cost reported.

The gram per mile reduction that was estimated was converted to a ton per year value using an assumed annual mileage accumulation rate of 12,000 miles/year. Using the cost per vehicle and the emission reduction per ton per vehicle, the cost per ton of reduction was calculated. These are shown in Table 3.1.5. Arizona's I/M program experienced a waiver rate of about 4%. The assumptions in this calculation tested at two different waiver rates: 0% and 5%. Hence, the cost per vehicle obtained from Harrington et al. (1999) could be used for this calculation where the waiver rate was 5%. For a 0% waiver rate, the costs would be higher than calculated.

Table 3.1.4. Cost Estimate Per Vehicle

	From Arizona Document	Conversion factor to convert 1996 dollars to 2002 dollars	Dollars in 2002	Value Used in this calculation
Inspection Cost per vehicle[1]	$ 16.75	1.147	$ 19.21	$ 20.00
Mean Repair Costs[2]	$ 123.00	1.147	$ 141.08	$ 145.00
Assumed Stringency	26.00%			26%
Mean Repair Costs per vehicle = Stringency*Repair cost				$ 37.70
Total cost per vehicle				$ 57.70

1. Inspection cost does not include waiting and travel time costs

2. Mean Repair Costs include imputed costs (Costs estimated when the vehicle showed repairs, but didn't report any cost)

Table 3.1.5. Cost Estimate Per Ton of Pollutant Reduced

Pollutant	Estimated g/mile reduction in 2007	AMAR (mi/yr)	tons/yr reduction per 1000 vehicles	$/ton reduced 5% waiver rate	
				5% waiver	0% waiver
NO_x	0.141	12000	1.87	$ 30,937	>= $ 30,937
VOC	0.315	12000	4.17	$ 13,848	>= $ 13,848
CO	3.299	12000	43.64	$ 1,322	>= $ 1,322

3.1.5. Conclusions

Although the cost per ton of NO_x reduced seems prohibitive, this might be an option worth pursuing due to the facts noted below:

- This option reduces emissions of other pollutants in addition to just NO_x.
- Implementation of I/M program promises a far greater reduction in the emissions compared to a case with no I/M program, as shown by Figures 3.1.1 and 3.1.2, and Table 3.1.2.

The percent reductions shown are relative to a case where no I/M program is in place. Hence, for those locations that already have a basic I/M program and choose to upgrade to the proposed stringent I/M program, the percent reduction gained will not be as high as shown in the table.

3.1.6. References

1. W.T. Davis, T.L. Miller, G.D. Reed, A.M.Y. Tang, P. Doraiswamy and P.Sanhueza, Effects of Growth in VMT and New Mobile Source Emission Standards on NO_x and VOC Emissions in Tennessee, 1999-2030 (Based on MOBILE6-Final Version), Report submitted to the Tennessee Department of Transportation, March 14, 2002.

2. Winston Harrington, Virginia McConnell and Amy Ando, "The Enhanced I/M Program in Arizona: Costs, Effectiveness, and a Comparison with Pre-regulatory Estimates", Discussion Paper 99-37, *Resources For the Future*, Washington DC, June 1999. Obtained from the Internet at http://www.rff.org/environment/air.htm, accessed March 20th, 2003.

3. Robert C. Sahr, Consumer Price Index (CPI) *Conversion Factors 1800 to estimated 2013 to Convert to Dollars of 2002*, Oregon State University, OR. Feb 2003. Obtained from the Internet at http://oregonstate.edu/Dept/pol_sci/fac/sahr/sahr.htm, accessed March 20th, 2003.

3.2 Additional Controls on Electrical Generating Utility Sources

There are currently three power plants (EGUs) in Tennessee that have not been controlled as a result of the NOx SIP call. These include John Sevier in East TN, Gallatin in Middle TN and Johnsonville in Middle/West TN. These plants currently emit approximately 127 tpd of NOx during the ozone season. Assuming that SCR could be installed on these plants with a 75% control efficiency, the reduction in NOx would be approximately 95 tpd which is a 6.6% decrease in the emissions estimated to occur in 2007 (1439 tpd statewide). In general the SCR can be applied to large boilers at a cost of less than $2000/ton of NOx removed. Further investigation would be required to determine if any of the uncontrolled EGUs in TN could be retrofitted with SCR or comparable control technologies. Since these sources were not controlled as a result of the NOx SIP call, a separate regulation would be required by the TDEC Division of Air Pollution Control and the State Air Board. None of the plants fall within the jurisdiction of a local air agency.

Table 3.2 Uncontrolled EGU Sources in Tennessee

TPY	Name	County	ID	Latitude	Longitude	Controls
20461	Tva Johnsonville Steam Plant	Humphreys Co	47-085-0011	36.0278	-87.9867	
14207	Tva Gallatin Steam Plant	Sumner Co	47-165-0025	36.3153	-86.4006	LNB
11784	Tva-John Sevier	Hawkins Co	47-073-0007	36.4181	-82.9471	

3.3 Additional Controls on Industrial Sources of NOx

There are currently approximately thirty five NOx sources in TN that are non-EGU sources which each emit greater than or equal to one tpd of NOx that were not subject to the NOx SIP call. The total emissions from these sources are approximately 161 tpd of NOx during the ozone season. Assuming that 50% of these plants as a group might be retrofitted with some type of NOx control technology and that these technologies would reduce NOx emissions by 50% (i.e., low NOx burners, fuel additives, etc), the reduction in NOx would be 40.4 tpd which is 2.8% of the 1439 tpd estimated to be emitted statewide in 2007. Further investigation would be required to determine if any of these uncontrolled industrial NOx sources could be retrofitted to control NOx. Estimated cost for control of these size sources is $2000 to $4000/ton of NOx reduced. Table 3.3.1 summarizes these sources as listed on the 1999 EPA website www.epa.gov/air/data for Tier 2 emissions for the State of Tennessee.

Table 3.3 Non EGU Sources with Greater Than 1 TPD of NOx Emissions in TN

These sources are not subject to the NOx SIP call

TPY	Name	County	ID	Latitude	Longitude
6257	Tenneco Gas	Sumner Co	47-165-0008	36.6156	-86.5594
4340	Tennessee Gas Pipeline (#79)	Perry Co	47-135-0001	35.7831	-87.8011
4008	E.I. Dupont De Nemours & Intermediates	Shelby Co	47-157-0097	35.2694	-89.9747
3631	Tenneco Gas / Environmental Department	Hickman Co	47-081-0002	35.8456	-87.4442
3451	Ford Motor Co	Davidson Co	47-037-0040	36.1833	-86.8732
2973	Dixie Cement Co. Knoxville, Tn	Knox Co	47-093-0008	36.0225	-83.8408
2616	Tenneco Gas	Wayne Co	47-181-0001	35.0244	-87.7508
2606	Basf Fibers Hwy 160 Lowland	Hamblen Co	47-063-0022	36.1517	-83.2075
2221	American Natural Resources Co.	Henry Co	47-079-0024	36.385	-88.4828
2199	Procter & Gamble Cellulose Company	Shelby Co	47-157-0055	35.158	-89.9631
2068	Anr Pipeline Company	Haywood Co	47-075-0053	35.6099	-89.2856
2060	Tenn Eastman Co Po Box 511 Kingspor	Sullivan Co	47-163-1007	36.5269	-82.5447
1996	Columbia Gulf Transmission Company	Maury Co	47-119-0095	35.6414	-87.2639
1722	Texas Gas Transmission Corporation	Tipton Co	47-167-0067	35.5222	-89.5761
1544	Aluminum Company Of America North Plant	Blount Co	47-009-0090	35.8133	-83.9208
1468	Arcadian Corporation	Shelby Co	47-157-0146	35.2833	-89.9643
1405	Holston Army Amm Plt	Sullivan Co	47-163-0018	36.5286	-82.5525
1198	Tn Gas Pipeline Co	Hardeman Co	47-069-0006	35.0378	-88.8911
1075	Signal Mtn Cement	Hamilton Co	47-065-3070	35.1008	-85.3422
904	Aluminum Company Of America South Plant	Blount Co	47-009-0008	35.6686	-83.9486
881	E. I. Du Pont De Nemours And Company	Humphreys Co	47-085-0007	36.0453	-87.9814
809	Nashville Thermal Transfer Corp	Davidson Co	47-037-0050	36.16	-86.7728
715	Mapco Petroleum, Inc.	Shelby Co	47-157-0101	35.085	-90.0825
709	East Tn Natural Gas	Sullivan Co	47-163-0110	36.4422	-82.5242
674	Holston Army Amm Plt	Hawkins Co	47-073-0028	36.5294	-82.6131
643	Texas Gas Trans Corp	Obion Co	47-131-0101	36.2367	-89.0286
604	Texas Eastern Gas Pipeline Gladeville	Wilson Co	47-189-0093	36.0911	-86.4181
536	Holston Army Amm Plt	Hawkins Co	47-073-1029	36.5319	-82.6475
516	E I Dupont	Hamilton Co	47-065-2730	35.1131	-85.2433
497	University Of Tennessee Steam Plant	Knox Co	47-093-0018	35.9494	-83.9258
474	Tenn Luttrell Co	Union Co	47-173-0028	36.2117	-83.7342
469	Trunkline Gas Co	Dyer Co	47-045-0092	36.0331	-89.3542
464	North American Rayon	Carter Co	47-019-0002	36.3511	-82.2447
451	Tenneco Gas/Midwestern Gas Transmission	Sumner Co	47-165-0014	36.6156	-86.5594
427	Humko-Div Witco Chem	Shelby Co	47-157-0150	35.1669	-89.9589
362	Goodyear Tire & Rubb	Obion Co	47-131-0012	36.4494	-89.0608

3.4 Alternative Fuels for On-Road Mobile Sources

Some fuels can be substituted for conventional gasoline and diesel fuel to achieve a reduction in mobile source emissions. These alternative fuels include biodiesel, ethanol, liquefied natural gas (LNG), compressed natural gas (CNG), and propane. Biodiesel is a fuel containing vegetable oil (corn, soy, canola, etc) either 20% by weight in B20 (80% diesel) or 100% biodiesel called B100. EPA has tested emissions from vehicles utilizing these alternative fuels and published "Fact Sheets" indicating summarizing the emission reductions achievable and the estimated costs. These Fact Sheets are available on EPA's "Alternative Fuels Web Site" at www.epa.gov/altfuels/altfuels.htm. The percent reduction in emissions reported by EPA for several alternative fuels is summarized in the table below.

Fuel	**Percent Reduction in Emissions Reported**			
	NOx	**CO**	**VOC**	**PM**
Biodiesel B20	2	10	10	15
Biodiesel B100	9	50	40	70
Ethanol E85	10	40	varies	20
Liquified Natural Gas	50	NA	50	50
Compressed Natural Gas	45	94	65	NA
Propane (Rich Adjust)	lower	higher	higher	NA
Propane (Lean Adjust)	higher	lower	lower	NA

Use of these alternative fuels requires new fueling stations as well as modifications to the vehicles burning the fuels. In some cases the alternative fuels have higher costs per equivalent heat value of gasoline or diesel. B100 biodiesel is typically \$2 to \$3 per gallon, 33% to 100% higher than diesel fuel. B20 is \$.20 to \$.30 per gallon higher than diesel fuel. Propane cost is typically \$.30 per equivalent gallon higher cost. CNG cost in the Knoxville is currently \$1.35 per diesel equivalent gallon not including highway taxes which are currently \$.38/gal of gasoline. LNG cost is generally about the same as diesel.

Modifications required to vehicles burning alternative fuels can be minimal or quite extensive depending on the fuel and the vehicle. The largest NOx emission reduction comes from burning LNG. LNG fueled heavy-duty trucks and buses can cost an additional \$30,000 to \$50,000. Fuel dispensing and fuel storage required for LNG typically costs \$15,000 to \$22,000 per vehicle.

Tons per day of NOx emission reductions can be estimated for an LNG fueled bus. A new (2006 model) diesel fueled bus in 2007 will have NOx emissions of 9.5 g/mile (under National default conditions) and travel an average 124 miles/day. An LNG fueled bus should have 50% lower NOx emissions (i.e. 4.75 g/mile). The emission reduction per bus is 4.75 g/mile x 124 miles/day = 589 g/day. If 100 buses in the study area are converted to LNG, the emission reduction will be 58.9 kg/day or 0.065 tons/day.

The cost of the 0.065 ton/day emission reduction can be estimated from the higher cost of an LNG modified vehicle. Ignoring the fuel dispensing and storage costs, the added capital cost of $40,000 per bus can be amortized over the life of the bus. If the bus service life is 400,000 miles, the added capital cost of the vehicle is $.10/mile. For 100 trucks, each traveling 124 miles/day, the total cost is $.10/mile x 100 buses x 124 miles/day = $1240/day. The cost per ton of emission reduction is $1240/0.065 tons = $19,000 per ton NOx.

Emission reductions of NOx from CNG should be almost as high as with LNG, but the NOx emission reductions for the other alternative fuels will be less. For this reason, additional analyses for the other fuels were not undertaken.

3.5 Low Emission Vehicles in Public and Private Fleets

Programs designed to encourage the replacement of old conventional gasoline and diesel fueled vehicles with lower emission vehicles can reduce area-wide emissions. Replacement vehicles may include electric vehicles with zero emissions, low emission vehicle technologies such as hybrid vehicles, or simply replacing the old fleet with newer lower emission vehicles on an accelerated schedule. Mechanisms for accomplishing the replacement of old vehicle fleets may be voluntary or may be regulatory driven by requiring permits and plans by fleet owners to replace high emission vehicles. Low emission vehicles can be used to replace heavy-duty trucks, diesel transit buses, school buses, heavy-duty gasoline trucks, light-duty trucks, or passenger vehicles. The greatest emission reductions will come from programs that replace vehicles that are 11 years old or older with new low emission vehicles. The table below shows the emission factors for 1-year old and 11-year old vehicles in 2007 based on the MOBILE6 emissions model (all National default conditions). Also shown in the table are the typical miles/day driven by a 11-year old vehicle of each type and the reduction in daily emissions when a 11-year old vehicle is replaced with a 1-year old vehicle.

Vehicle Type	Miles/Day	NOx Emissions (g/mile)	(g/day)
11-Year Old Vehicles (model year 1996):			
Heavy-Duty Diesel Truck HDDV8b	115	20.0	2300
Diesel Transit Bus HDDBT	89	21.0	1870
Diesel School Bus HDDBS	27	14.7	397
Heavy-Duty Gasoline Truck HDGV2b	29.5	4.83	142
Passenger Car LDGV	24.3	1.1	26.7
1-Year Old Vehicles (model year 2006):			
Heavy-Duty Diesel Truck HDDV8b	115	6.49	746
Diesel Transit Bus HDDBT	89	4.49	400
Diesel School Bus HDDBS	27	6.70	181
Heavy-Duty Gasoline Truck HDGV2b	29.5	0.68	20
Passenger Car LDGV	24.3	0.044	1.1
Emission reductions from replacing an 11-yr old vehicle with a 1-yr old vehicle:			
Heavy-Duty Diesel Truck HDDV8b			1900
Diesel Transit Bus HDDBT			1470
Diesel School Bus HDDBS			216
Heavy-Duty Gasoline Truck HDGV2b			122
Passenger Car LDGV			25.6

These emission reductions can be calculated in tons/day per 100 vehicles replaced in a fleet. The table below shows the expected NOx emission reductions achievable if 11-year old vehicles are replaced with either zero emission vehicles (ZEVs) or with 1-year old conventional vehicles. If vehicles are replaced with ZEVs the total daily emissions per vehicle are eliminated. If the vehicles are replaced with conventional vehicles, the emission reduction achieved is the difference between daily emissions from the old vehicle minus the daily emissions from the new vehicle.

Vehicle Type		NOx Emission Reductions Per 100 Vehicles Replaced in With New ZEVs (tons/day)	Conventional Vehicles (tons/day)
Heavy-Duty Diesel Truck	HDDV8b	0.25	0.21
Diesel Transit Bus	HDDBT	0.21	0.16
Diesel School Bus	HDDBS	0.044	0.024
Heavy-Duty Gasoline Truck	HDGV2b	0.016	0.013
Passenger Car	LDGV	0.0029	0.0028

It is clear from the results shown in the table above that the additional benefit of ZEVs is small compared to simply replacing old vehicles with new vehicles. There is a cost associated with the replacement, but it is not likely that the entire cost of replacing an old vehicle with a new vehicle would be attributable to the desire to reduce emissions. Other gains would be achieved by purchasing new vehicles including better fuel economy, improved safety, lower repair cost, and increased reliability. The differential cost of the ZEV vehicle would be thousands of dollars per vehicle, while the additional emission reduction is small. The cost per ton of additional NOx reduction would likely be greater than $100,000 per ton but it is difficult to quantify.

3.6 Lower Speed Limit for Heavy-Duty Trucks on Rural Interstates

On-road mobile source emissions vary considerably as a function of vehicle speed. The highest emissions of NOx occur at high vehicle speeds such as occur on interstates and freeways. Measured in grams per mile, NOx emissions are lowest around 35 mph, and higher at both higher and lower vehicle speeds. VOC emissions follow a different pattern. VOC emissions are lowest at high speeds and highest at low speeds. The table below shows typical NOx and VOC emission factors for different vehicle types as a function of average speed as predicted by the MOBILE6 model for 2007.

2007 Emission Factors from MOBILE6 by Vehicle Type for Freeways Only

SPEED (mph)	NOx LDGV (g/mile)	NOx LDGT34 (g/mile)	NOx HDGV (g/mile)	NOx HDDV (g/mile)	VOC LDGV (g/mile)	VOC LDGT34 (g/mile)	VOC HDGV (g/mile)	VOC HDDV (g/mile)
5	1.368	2.134	2.498	14.644	3.527	5.277	5.819	1.296
15	0.727	1.257	2.751	10.900	1.440	2.376	2.601	0.817
25	0.725	1.270	3.004	9.243	1.141	1.986	1.810	0.562
35	0.713	1.268	3.257	8.840	1.024	1.818	1.491	0.422
45	0.729	1.295	3.510	9.507	0.955	1.730	1.330	0.346
55	0.750	1.329	3.764	11.555	0.900	1.646	1.240	0.310
65	0.773	1.369	4.017	16.046	0.863	1.579	1.211	0.303
Percent change for lowering speed limit from 65 to 55 mph:								
	-3.0	-2.9	-6.3	-28.0	4.3	4.2	2.4	2.3

Footnote:
MOBILE6 (Version Jan 20, 2002) National Default Settings, 60/93 Min/Max Temp, RVP = 9.
Run for Freeways Only at various average speeds.

As can be seen from the table above, NOx emissions are higher at 65 mph versus 55 mph. This is especially true for heavy-duty diesel trucks (HDDVs) that have 28 percent lower NOx emissions at 55 mph versus 65 mph. Heavy-duty diesel trucks also have much higher NOx emissions than passenger vehicles and typically contribute more than 65 percent of NOx emissions on Tennessee interstates. Speed limits on Tennessee interstates are typically 70 mph in rural areas and 55 mph in urban areas. The MOBILE6 model will not calculate emissions at speeds above 65 mph, so emissions at 70 mph could not be determined.

Lowering the speed limit for heavy-duty trucks to 55 mph on rural interstates could significantly reduce NOx emissions. The table above shows that NOx emissions in g/mile are 28% lower for heavy-duty diesel (HDDV) trucks and 6.3% lower for heavy-duty gasoline trucks (HDGV) at 55 mph versus 65 mph. Lower speeds result in a small increase in VOC emissions of 2.3 to 2.4 percent.

How this affects area-wide NOx emissions can be illustrated for an area like the Knoxville EAC area. In the Knoxville EAC area, on-road mobile sources account for 71.49 tons/day of NOx emissions, an amount equal to 45.2% of the 158 tons/day from all sources in the area. HDDVs on rural interstates account for 20.6 tons/day of NOx emissions. This equals 28.8% of all on-road mobile source emissions in the area (including other road types). A 28% reduction in these emissions (due to lowering the speed limit to 55 mph) would yield an overall reduction of area-wide NOx emissions of:

HDDVs -28% x 20.6 tons/day = -5.77 tons/day or

100% x 5.77 / 158 = 3.65% reduction in area-wide emissions.

Heavy duty gasoline trucks on rural interstates in the Knoxville EAC area account for 0.86 tons/day of NOx. A 6.3% reduction in these emissions (due to lowering the speed limit to 55 mph) would yield an overall reduction of area-wide NOx emissions of:

HDGVs -6.3% x 0.86 tons/day = -0.054 tons/day or

100% x .054 / 158 = 0.034% reduction in area-wide emissions.

The total expected reduction in 2007 NOx emissions in the Knoxville EAC area due to lowering the speed limit for trucks to 55 mph on rural interstates is 3.68%.

Heavy-duty trucks on rural interstates account for 0.52 tons/day of VOC emissions in the Knoxville EAC area. These emissions would be expected to increase 3.4%. VOC emissions from all vehicles and roadway types are 41.52 tons/day. The expected increase in VOC emissions from all on-road mobile sources would be only 0.04%.

Lowering the speed limit on rural interstates would require an act of the state legislature. The lowering of the speed limit would not have to be a permanent and it could only be lowered during the summer ozone season.

The cost of lowering the speed limit for trucks on rural interstates is difficult to assess. There would be costs to state government of replacing speed limit signs. Lower speed limits would probably increase fuel economy (actually lowering costs) and improve safety. The cost to truckers would be primarily the extra travel time to deliver cargo. To truckers “time is money” and the costs may be very significant. It is likely that truckers would be strongly opposed to a plan to lower speed limits on rural interstates.

3.7 Lower Speed Limit for All Vehicles on Rural Interstates

As discussed in Section 3.6, on-road mobile source emissions vary considerably as a function of vehicle speed. The highest emissions of NOx occur at high vehicle speeds such as occur on interstates and freeways. Measured in grams per mile, NOx emissions are lowest around 35 mph, and higher at both higher and lower vehicle speeds. VOC emissions follow a different pattern. VOC emissions are lowest at high speeds and highest at low speeds. The table below shows typical NOx and VOC emission factors for different vehicle types as a function of average speed as predicted by the MOBILE6 model for 2007.

2007 Emission Factors from MOBILE6 by Vehicle Type for Freeways Only

SPEED (mph)	NOx LDGV (g/mile)	NOx LDGT34 (g/mile)	NOx HDGV (g/mile)	NOx HDDV (g/mile)	VOC LDGV (g/mile)	VOC LDGT34 (g/mile)	VOC HDGV (g/mile)	VOC HDDV (g/mile)
5	1.368	2.134	2.498	14.644	3.527	5.277	5.819	1.296
15	0.727	1.257	2.751	10.900	1.440	2.376	2.601	0.817
25	0.725	1.270	3.004	9.243	1.141	1.986	1.810	0.562
35	0.713	1.268	3.257	8.840	1.024	1.818	1.491	0.422
45	0.729	1.295	3.510	9.507	0.955	1.730	1.330	0.346
55	0.750	1.329	3.764	11.555	0.900	1.646	1.240	0.310
65	0.773	1.369	4.017	16.046	0.863	1.579	1.211	0.303
Percent change for lowering speed limit from 65 to 55 mph:								
	-3.0	-2.9	-6.3	-28.0	4.3	4.2	2.4	2.3

Footnote:
MOBILE6 (Version Jan 20, 2002) National Default Settings, 60/93 Min/Max Temp, RVP = 9.
Run for Freeways Only at various average speeds.

As can be seen from the table above, NOx emissions are higher at 65 mph versus 55 mph. This is especially true for heavy-duty diesel trucks (HDDVs) that have 28 percent lower NOx emissions at 55 mph versus 65 mph. Heavy-duty diesel trucks also have much higher NOx emissions than passenger vehicles and typically contribute more than 65 percent of NOx emissions on Tennessee interstates. Speed limits on Tennessee interstates are typically 70 mph in rural areas and 55 mph in urban areas. The MOBILE6 model will not calculate emissions at speeds above 65 mph, so emissions at 70 mph could not be determined.

Lowering the speed limit for heavy-duty trucks to 55 mph on rural interstates could significantly reduce NOx emissions. The table above shows that NOx emissions in g/mile are 28% lower for heavy-duty diesel (HDDV) trucks and 6.3% lower for heavy-duty gasoline trucks (HDGV) at 55 mph versus 65 mph. Lower speeds result in a small increase in VOC emissions from heavy-duty trucks of 2.3 to 2.4 percent.

Lowering the speed limit for light-duty passenger vehicles (cars, pickup trucks, and SUVs) to 55 mph on rural interstates could also reduce NOx emissions. The table above shows that NOx emissions in g/mile are 2.9 to 3.0% lower for light-duty vehicles (LDGV and LDGT34) at 55 mph versus 65 mph. Lower speeds result in an increase in VOC emissions from light-duty vehicles of 4.2 to 4.3 percent.

How lowering the rural interstate speed limit for all vehicles affects area-wide NOx emissions can be illustrated for an area like the Knoxville EAC area. In the Knoxville EAC area, on-road mobile sources account for 71.49 tons/day of NOx emissions, an amount equal to 45.2% of the 158 tons/day from all sources in the area. HDDVs on rural interstates account for 20.6 tons/day of NOx emissions. This equals 28.8% of all on-road mobile source emissions in the area (including other road types). A 28% reduction in these emissions (due to lowering the speed limit to 55 mph) would yield an overall reduction of area-wide NOx emissions of:

HDDVs -28% x 20.6 tons/day = -5.77 tons/day or

100% x 5.77 / 158 = 3.65% reduction in area-wide emissions.

Heavy duty gasoline trucks on rural interstates in the Knoxville EAC area account for 0.86 tons/day of NOx . A 6.3% reduction in these emissions (due to lowering the speed limit to 55 mph) would yield an overall reduction of area-wide NOx emissions of:

HDGVs -6.3% x 0.86 tons/day = -0.054 tons/day or

100% x 0.054 / 158 = 0.034% reduction in area-wide emissions.

Light-duty gasoline vehicles on rural interstates in the Knoxville EAC area account for 1.74 tons/day of NOx . A 3.0% reduction in these emissions (due to lowering the speed limit to 55 mph) would yield an overall reduction of area-wide NOx emissions of:

LDGVs -3.0% x 1.74 tons/day = -0.052 tons/day or

100% x 0.052 / 158 = 0.033% reduction in area-wide emissions.

Light-duty gasoline trucks (LDGT12 and LDGT34) vehicles on rural interstates in the Knoxville EAC area account for 2.78 tons/day of NOx . A 2.9% reduction in these emissions (due to lowering the speed limit to 55 mph) would yield an overall reduction of area-wide NOx emissions of:

LDGTs -2.9% x 2.78 tons/day = -0.081 tons/day or

100% x 0.081 / 158 = 0.051% reduction in area-wide emissions.

The total expected reduction in 2007 NOx emissions in the Knoxville EAC area due to lowering the speed limit for all vehicles to 55 mph on rural interstates is 5.96 tons/day or 3.76%.

Heavy-duty trucks on rural interstates account for 0.52 tons/day of VOC emissions in the Knoxville EAC area. These emissions would be expected to increase 3.4% or 0.018 tons/day. Light-duty vehicles on rural interstates account for 4.95 tons/day of VOC emissions in the Knoxville EAC area. These emissions would be expected to increase 4.3% or 0.21 tons/day. VOC emissions from all vehicles and roadway types are 41.52 tons/day. The expected increase in VOC emissions from all on-road mobile sources is 0.228 tons/day or 0.55%.

Lowering the speed limit on rural interstates would require an act of the state legislature. The lowering of the speed limit would not have to be a permanent and it could only be lowered during the summer ozone season.

The cost of lowering the speed limit for all vehicles on rural interstates is difficult to assess. There would be costs to state government of replacing speed limit signs. Lower speed limits would probably increase fuel economy (actually lowering costs) and improve safety. The cost to truckers would be primarily the extra travel time to deliver cargo. The cost to drivers and passengers in light-duty vehicles would be the extra time it takes to reach their destinations. To everyone involved “time is money” and the costs of increasing travel time may be very significant. It is likely that most drivers would be strongly opposed to a plan to lower speed limits on rural interstates.

3.8 Diesel Cetane Additive

A program has been initiated for the summer of 2004 in the East Tennessee area led by Mr. Ben Henneke of Clean Air Action Corporation (Tulsa Ok) to introduce a diesel fuel cetane additive into the diesel fuel delivered to diesel refueling stations. The cetane additive requires no infrastructure as it is introduced directly into the fuel at the distribution point. The additive, while theoretically increasing the cost of the fuel by approximately one cent per gallon, will not increase the cost at the present time. The pilot program is being funded by the fact that the estimated 3% reduction in NOx emissions is being utilized in a NOx trading program. Ten percent of the estimated NOx reduction is being retired (no longer able to used as an allowable credit), whereas the remainder (2.7%) is providing useable NOx credits for use by electric generating utilities. Assuming a cost of $.01/gallon, a fuel usage of 6 mpg, a speed of 55 mph, 673 g NOx/hour, and a 3% reduction in NOx emissions due to the cetane additive, the cost of this control measure is estimated to be $4119/ton. The effect on particulate matter is minimal. The actual reduction in NOx is a function of the specific year of application, the fraction of HDDV with exhaust gas recirculation, the average cetane number of the diesel fuel and the amount of cetane additive (which affects the cetane number). EPA estimates found in the report, *The Effect of Cetane Number Increases Due to Additives on NOx Emissions from Heavy Duty Highway Engines*—EPA420-S-02-012, June 2002, showed an estimated reduction of 2 % in 2003 and 1.4% in 2007 using a base cetane number of 45. More detailed calculations would need to be conducted to confirm the 3% number being used in the pilot program.

Discussions are being held at the national policy level (U.S. EPA and others) to determine how such a program would be credited to local areas given the fact that fuel purchased in East TN, particularly with respect to diesel fuel, would be only partially consumed within the local area. Thus the question arises as to whether the 3% reduction can be claimed for the local area or only the fraction that is used in the local area. Discussions are in progress to determine the appropriate way to handle this. Can the local EAC or region claim all of the credit, or can they claim a part and pass on some credit to an adjacent or reasonably adjacent EAC or area, or can they only claim a fraction and no one else gets a credit. This same dilemma exists for I/M programs, where the question arises as to what percent of the vehicles are subject to an I/M program.

Aside from the uncertainty as to whom gets the credit, it would appear that the cetane program is a viable approach for reducing NOx emissions and could be utilized as an NOx reduction strategy as opposed to the current approach, which is to be utilized as a means of generating allowable emission credits. On a statewide basis, emissions from HDDV (the primary users of diesel fuel) are approximately 57% (300 tons/day) of the 529 tons/day of NOx emitted from the on-road source category in 2007. A 3% reduction in NOx would then be 9 tons/day or 0.6% of the total statewide NOx emissions. As a further example, for the Knoxville EAC, the emissions reduction associated with a 3% reduction in HDDV NOx emissions would represent approximately 1.2 tons/day of emissions, or approximately 0.8% of the total emissions of NOx from the EAC area. Again, these calculations assume that the reduction could be credited to the area that supplied the cetane additive. An additional benefit, not yet quantified, is that the additive would also reduce emissions from the non-road source category, since many of these sources utilize diesel fuel. Diesel fuel is responsible for approximately 90% of off-road NOx emissions. On a statewide basis, a 3% reduction in NOx emissions from 90% of the off-road sources is an additional 10.4 tons per year or another 0.7% of the total NOx emissions. Fuels applied to non-road vehicles would, for the most part, be utilized within the application area. Thus the total effect of cetane additive from on-road and off-road mobile sources is 1.3%.

The political issues associated with the cetane additive program are as follows. First, the additive would likely need to be provided and required of all suppliers within a region, thus the requirement crosses over jurisdictional boundaries. For example, the pilot program encompasses all of East Tennessee due to the central location of major distributors. Legal requirements would need to be implemented much like the current requirements for low RVP gasoline used in current areas requiring I/M, so there is precedence within the state for fuel requirements. Second, the question of how much credit can be claimed by the local area, due to the fact that some vehicles would leave the local area, must be resolved. At minimum, areas should be able to utilize the fraction of the benefit that is estimated to occur within the area. Third, the current pilot program is essentially being conducted for the primary purpose of creating useable emission credits, with only a small fraction being retired. This allowable emission credit program would need to be eliminated, if the reductions are to be used as an emission reduction for attainment purposes.

3.9 Effect of a Stage II Vapor Recovery

3.9.1. Introduction

Stage II vapor recovery at gasoline stations captures the VOC vapors during refueling and prevents it from escaping to the atmosphere. The implementation of Stage II controls in those areas that do not currently have Stage II controls will result in reduced VOC emissions. This section summarizes the reductions that might be achieved through Stage II controls.

3.9.2. Stage II Controls – Model Runs

The on-road emission factor model, MOBILE6.2, was used to identify the emissions reductions associated with Stage II controls. The MOBILE6.2 model runs were done for the analysis years 2007. A base-case run represented a scenario with no Stage II controls and a fuel RVP of 9.0psi. Most of the parameters were set to national default values in the MOBILE6.2 model. For those parameters that required a mandatory input, Table 3.9.1 lists the input parameters that were used in the model runs.

It is assumed that the Stage II Program will begin in the year 2004 and will be phased in over a period of 3 years. The program is assumed to be 80% efficient for LDGV and LDGT and about 60% efficient for HDGV. A base-case run was conducted for a fuel RVP of 9.0 psi followed by two runs with Stage II controls in place for a fuel RVP of 9.0 and 7.8 psi. In addition, a model run was conducted assuming Stage II controls in addition to the proposed "stringent I/M" program with a 5% waiver, described in Section 3.1.

Table 3.9.1. Input Parameters used in MOBILE6.2 model runs

Parameter	**Value**
Analysis Year	2007
Min/Max Temperature (deg F)	60/93
Evaluation Month	7
Fuel RVP (psi)	9.0 or 7.8
Stage II Program Start Year	2004
Phase-in Period	3 Years
Percent Efficiency for LDGV and LDGT	80%
Percent Efficiency for HDGV	60%

3.9.3. Model Results – Emissions Reduction

The MOBILE6.2 model lists the emission factors in terms of grams of pollutant per vehicle mile traveled. The model results are shown in Table 3.9.2. The results show that the implementation of Stage II controls with the assumptions stated above resulted in about 5.3% reduction in VOC emissions for a fuel RVP of 9.0 psi compared to the base case with no Stage II controls. Lowering the fuel RVP to 7.8 psi showed an estimated reduction of about 14.9% in VOC emissions, although much of this is attributable to the lower RVP. Implementation of the Stage II controls in addition to the proposed stringent I/M program (section 3.1) resulted in about 29.7% reduction in VOC emissions compared to the base case. It must be noted that the stringent I/M program alone, showed an estimated 25% reduction in VOC emissions.

Table 3.9.2. Model Results and Emission Reduction Summary

(a). Emission Factor

Scenario	**RVP (psi)**	**Emission Factor in grams/mile**		
		NO_x	**VOC**	**CO**
Base Case	9.0	1.743	1.244	12.779
With Stage II	9.0	1.743	1.178	12.779
With Stage II	7.8	1.738	1.059	12.050
With Stage II and Stringent I/M, 5% waiver	7.8	1.602	0.874	9.480

(b). Percent Reductions and Ton/Day Reduction Per Million VMT

Scenario	**RVP (psi)**	**% Reduction Relative to Base Case and Ton/Day Reduction per Million VMT in brackets**		
		NO_x	**VOC**	**CO**
With Stage II	9.0	0% (0)	5.3% (0.07)	0% (0)
With Stage II	7.8	0.3% (0.01)	14.9% (0.20)	5.7% (0.80)
With Stage II and Stringent I/M, 5% waiver	7.8	8.1% (0.16)	29.7% (0.41)	25.8% (3.64)

3.9.4. Conclusions

Implementation of Stage II controls targets only the VOC emissions. As shown above, the percent reduction obtained through Stage II controls alone, is about 5.3% for VOC emissions and none for CO and NO_x. The positive impact of Stage II is likely to decrease in the future since vehicles now have on-board vapor recovery systems, essentially providing vapor recovery/control without the need for Stage II controls. EPA has indicated that it may revisit Stage II control requirements in the future, since the Stage II controls may become redundant as the older fleet is retired.

3.10 Nonroad Mobile Sources, Acceleration of Replacement/Retrofit of Older Equipment

Based on the emission inventory for Tennessee shown in Section 2.2, nonroad mobile sources account for approximately 24% of the statewide emissions of NOx. The national EPA program already requires that railroad engines be upgraded when rebuilt to meet lower emission standards. However, most of the new emission standards apply only to new nonroad sources that are purchased. The specific category of lawnmowers is discussed in Section 3.11. In light of this, some areas, such as California, have initiated programs to address the replacement and/or retrofit of older nonroad mobile sources. This concept could be implemented as a voluntary effort or could be mandated. A mandate would require very specific regulations, given the very broad category of sources in the nonroad mobile category (ranging from 2 cycle weed eaters to tractors to fork lifts to large earth moving equipment). It is beyond the scope of this report to address each of these. Information is very limited on the actual implementation of strategies to address this category. One recent presentation was made at the EPA Clearing the Path to Clean Air Conference in March 2003 by Mr. Tim Taylor, Mobile Source Division, of the Sacramento Air Quality District that provided a brief summary of programs that were being considered and the estimated cost of the programs in $/ton of NOx removed. The program included the following possible control strategies based on the general philosophy that "a rebuilt engine is a lost opportunity for improving emissions":

1. Purchase of new, lower emission vehicles as an alternative to rebuilding an existing engine. It was stated, however, that few off-road vehicles would be amenable to this approach. The estimated cost was $10000 to $13000/ton of NOx reduced based on the difference between new and existing emission factors.
2. Replacement of older engines with newer engines. The cost for large nonroad diesel engines was estimated to be $20K-$30K per vehicle with a $4000 to $10000/ton of NOx cost.
3. Utilize emulsified fuels such as PuriNOx. The emulsified fuels (which include adding a mixture of water and additive to diesel fuel were estimated to cost approximately 25-30 cents per gallon. It was estimated that this would achieve a 14-35% NOx reduction and a 30-63% PM reduction. The additive was estimated to result in a 15% decrease in hp, an increase in operating cost, and would require infrastructure to provide for mixing.
4. Lean NOx catalyst add-on. This program would involve the addition of a retrofit catalyst to existing engines. The cost was estimated to be $10000 to $13000/ton of NOx. It was reported that while pilot programs had been tested, the retrofit program was not commercially available.

Additional investigation would be needed to determine if these types of programs could really be implemented as the cost of such a program would likely be substantial to the individual owners of the vehicles or equipment.

3.11 Lawnmower Rebate/Buy Back Program

Lawnmower Rebate or Buy Back programs have been initiated and reported in several areas within the United States, including San Diego County CA, Allegheny County PA, Chicago IL, and other areas. For the most part, these programs have been implemented on a relatively small scale with typical reports of 500-700 gasoline-powered lawnmowers having been removed in a typical one-year program. These programs are generally operated as volunteer programs in which the air quality agency or other local agencies provide a $60 to $75 rebate toward the purchase price of a new electric or battery powered lawnmower for citizens willing to turn in their gasoline powered mower.

A limitation of this type of program that needs to be considered before embarking on such a program is that there are currently only a limited number of electric lawnmowers that are available, particularly with respect to size of mower. A search of available mowers revealed that companies such as Lowe's, Home Depot, Sears, and others carry electric mowers manufactured by companies such as Bolens, Black and Decker, etc. All models were either 18" or 19" models with statements that these were generally restricted to small lawns. The models were priced in the $150 to $200 range for the push mowers powered by an electric cord to $510 for a model which was operated by an on-board rechargeable battery. No models were self-propelled. Most models were advertised to be suitable for a tenth of an acre up to a maximum of one third of an acre.

Given the limitation of availability of electric mowers, it was assumed that any participates would likely be replacing existing lawnmowers that were in the 3-6 hp range rather than larger hp mowers used to maintain larger lawns. Emissions for existing lawnmowers, based on the most recent EPA publication *Exhaust Emission Factors for Nonroad Engine Modeling – Spark Ignition, EPA420-P-02-015*, November 2002, are reported in g/hp-hr. For existing mowers in the 3-6 hp range, the emissions of HC, CO, NOx, and PM were reported as 8.4, 354, 3.6 and 0.06 g/hp-hr, respectively. Assuming that the mower has a 5 hp engine and that it is operated for 1 hour, the emissions would then be 42 g/hr HC, 1770 g/hr CO, 18 g/hr NOx, and 0.3 g/hr PM.

Since the electric mower operates on electricity, a calculation was done to determine the amount of NOx that would be emitted by a typical power plant in Tennessee to charge the battery of the electric mower to produce the equivalent of 5 hp for one hour. A 5.0 hp engine operating for one hour uses 12,600 btu of energy. Assuming a power plant that is 35% thermally efficient that is emitting 0.1 lb NOx/10^6 Btu (the latest emission standard for NOx), it is estimated that the power plant would emit 1.6 g of NOx in producing the power required to operate the mower for one hour. Thus the emissions to the environment would be reduced from 18 g/hr to 1.6 g/hr, or a 16.4 g reduction per hour of operation of the electric mower as compared to the gasoline powered mower. Given the very low emissions of HC, CO and PM from electric utilities, the reduction in emissions of these pollutants would be approximately equal to the emissions from the mower itself, without any correction.

In calculating an effective cost of reducing NOx in $/ton, it was assumed that the lawnmower rebate program would provide a $60 rebate for each participant in the lawnmower rebate/replacement program and that this is essentially the cost of the program. Assuming that the electric lawnmower has an 8 year life, and is operated for one hour per week for seven months (31 weeks) per year, the emissions from a single mower would be 16.4 g/hr x 31 hours per year x 8 years for a total of 4067 g or 0.0045 tons of NOx. On that basis, the cost would be $60/0.0045 tons or $13,333/ton, excluding any administrative cost of operating the volunteer program.

A calculation was also made to determine the NOx emission reduction that would result in tons/day for a program which effectively removed 500 gasoline mowers from the area in which it was being implemented. Five hundred electric mowers operated one hour per week would reduce NOx emissions by 500 x 16.4 g per week, or 1171 g/day. This would be equivalent to 0.0012 tons per day of NOx reduction in the area of interest.

The political issues associated with the lawnmower rebate program would appear to be minor. Such a program, if operated by an agency, would likely require approval of the agencies board, since the program would have a cost based on the number of lawnmowers which were turned in, plus the administrative cost of operation. This is, however, the type of program that might be operated by a volunteer group and possibly incorporated into existing volunteer programs such as home hazardous waste drop off programs. The biggest challenge would likely be the difficulty in assuring that the rebate legitimately replaced an existing lawnmower that was actually being used before it was turned in as opposed to a non-functioning lawnmower. The advantage is that it is only a rebate program; therefore the money is only spent if the participant actually purchases an electric mower.

Example Lawnmower Buy-Back Forms are included in the Appendix to this report.

3.12 Transportation Planning and Land Use Restrictions Designed to Hold the VMT Growth Rate to the Population Growth Rate

During the 1990's VMT growth rates in Tennessee and much of the United States have been growing at a higher rate than population growth, sometime by as much as twice the population growth rate. This growth in VMT is a result of more drivers per residence, and existing drivers driving more miles per year, than in the previous decade. The additional driving is related to in some cases to urban sprawl where people live farther from work, shopping, recreational and other destinations than in the past, and the fact that people choose to engage in more activities that require driving. Transportation planning and land use restrictions designed to reduce VMT generally involve restrictions on land use that force or encourage high density development of residences, shopping, recreational facilities, and work places that shorten the length of trips. The idea being that if people live closer to their desired destinations their trips can be shorter. Schemes to restrict the development of farm lands into residential areas, in favor of more densely developing existing urban areas, is sometimes thought to be beneficial in limiting sprawl. Other schemes, sometimes called "smart growth" are designed to better utilize and develop existing urban lands, increase the population density within a city, and thereby reduce the growth of VMT.

Current emission forecasts for most EAC areas in Tennessee include assumed future growth rates in VMT of 2 to 4 percent per year. Estimating the magnitude of VMT growth reductions that can be achieved by transportation planning and land use restrictions is beyond the scope of this report. Such plans would have to be incorporated into travel demand models to estimate the percentage of VMT reduction expected. The percent reduction in VMT growth can then be used to estimate the expected reduction in NOx emissions as follows.

In an EAC like Knoxville, 45.2% of NOx emissions are from on-road mobile sources. Forty percent of the on-road mobile emissions are from light duty vehicles including cars, vans, pickup trucks, and SUVs that would be used for commuting to school or work. It is likely that land use restrictions will eliminate primarily light-duty vehicle trips. Therefore, for each 1 percent reduction in light duty vehicle VMT, NOx emissions will be reduced by 1% x .452 x .40 = 0.18%. Knoxville EAC NOx emissions for 2007 have been predicted to be 158 tons/day, so a 1% reduction in light-vehicle VMT would reduce NOx emissions by 0.18% x 158 tons/day = 0.28 tons/day throughout the Knoxville EAC area.

3.13 Incentive Programs to Encourage Purchases of Low Emission Vehicles

EPA sets emission standards for new vehicles sold in the United States, but California has established even more stringent standards for vehicles sold in California. In the late 1990's California established the first low emission vehicle (LEV) standards. Recently, EPA adopted more stringent standards (called Tier 2 standards) that apply to all light-duty vehicles beginning with model year 2004. California has adopted even more stringent standards called LEV II standards. There are three levels of LEV II standards: LEV (low emission vehicle), ULEV (ultra-low emission vehicle), and SULEV (super-ultra-low emission vehicle). There is also a zero emission vehicle (ZEV) that is an electric vehicle with no emissions.

The attached table shows the EPA Tier 2 standards, the California LEV II standards and the differences between the two. The most stringent emission standards for non-electric vehicles are the LEV II SULEV standards. The only existing technology that can meet the SULEV standard is a hybrid vehicle using a combined electric motor and spark ignition engine that runs at optimum conditions. SULEV standards require emissions of VOC, CO and NOx that are 86.7%, 70.6%, and 71.4% lower than EPA Tier 2 standards, respectively.

Also shown in the table is the composite emission factor for all vehicles combined for 2007 based on all National default conditions in the MOBILE6 model. According to the National defaults, light-duty vehicles make up for 87% of on-road VMT, and each year about 7% of light-duty vehicles are replaced with new vehicles. Tier 2 standards begin in 2004. By 2007, three years of sales of vehicles meeting Tier 2 standards will have occurred, constituting 21% of the light-duty vehicle fleet. Therefore, the portion of all on-road mobile source emissions attributable to Tier 2 vehicles can be estimated as the emission standard times 21% of 87% = 0.183. These values are shown in table along with the percent of emissions attributable to Tier 2 vehicles in 2007.

The percent of emissions attributable to Tier 2 vehicles (as a percentage of emissions from the entire fleet including all vehicle types) is 1.1, 4.86, and 0.73 percent of VOC, CO and NOx, respectively. This is the maximum percent reduction in emissions achievable with any alternative technology, even ZEVs. The greatest reduction in emissions from LEV II vehicles would be from SULEVs. The additional reduction in on-road mobile source emissions from 3 years of SULEV sales substituting for 3 years of Tier 2 vehicle sales is 0.96, 3.43, and 0.52 percent for VOC, CO and NOx, respectively.

The cost to achieve the emission reductions from SULEV has been estimated based on the differential cost of a Honda CRV SULEV (hybrid) versus a conventional gasoline fueled Honda CRV. This differential cost is $6000. The lower SULEV emission standards must be met for 120,000 miles, so the added capital cost of purchasing a hybrid vehicle is $6000/120,000 miles = $.05/mile. Gas economy is reportedly 51 mpg for the hybrid vehicle and 39 mpg for the conventional vehicle. For gasoline at $2/gal, the fuel cost savings is $.012/mile. The capital cost difference minus the fuel savings equals $.038/mile. Dividing this by the grams of emission reductions per mile as shown in the table yields the cost per gram of emission reduction. Converting to $/ton of emission reduction yields a cost of $530,000 per ton of VOC reduced, $14,000/ton of CO reduced and $690,000/ton of NOx reduced.

States other than California may legislate more stringent emission regulations such as the LEV II standards. Tennessee would have to legislate these emission standards in order to achieve these small additional reductions in emissions.

Potential Emission Reductions From Sales of Low & Ultralow Emission Vehicles

Future Emission Standards for Light Duty Vehicles
Including EPA Tier 2 and California LEV II Standards
(These standards apply to all LDGVs and LDGTs < 8500 lbs.)

(Emissions Standards Shown are for the First 50,000 Miles or 5 Years)

		VOC (g/mile)	CO (g/mile)	NOX (g/mile)
EPA Tier 2 Standards (2004-2007 phase-in)		0.075	3.400	0.070
California LEV II Stds (2004-2007 phase-in)				
	LEV	0.075	3.400	0.050
	ULEV	0.040	1.700	0.050
	SULEV	0.010	1.000	0.020

Reduction in Emissions Achievable From Vehicles Meeting the California LEV II Standards Compared to EPA's Tier 2 Emission Standards:

		VOC (g/mile)	CO (g/mile)	NOX (g/mile)
California LEV II Stds (2004-2007 phase-in)				
	LEV	0.000	0.000	0.020
	ULEV	0.035	1.700	0.020
	SULEV	0.065	2.400	0.050

		VOC (%)	CO (%)	NOX (%)
California LEV II Stds (2004-2007 phase-in)				
	LEV	0.0	0.0	28.6
	ULEV	46.7	50.0	28.6
	SULEV	86.7	70.6	71.4

	VOC (g/mile)	CO (g/mile)	NOX (g/mile)
2007 MOBILE6 Emission Factors For All Vehicles Combined	1.241	12.779	1.743
87% of VMT is by LDVs. After 3 Years of Tier 2 Sales 21% of LDV VMT is Tier 2 Contribution of Tier 2 LDVs to E.F.	0.014	0.621	0.013

	VOC (%)	CO (%)	NOX (%)
Percent Emissions Due to Tier 2 LDVs	**1.10**	**4.86**	**0.73**
Percent Reduction in On-Road Mobile Emissions After			
3 Years of LEV Sales**	**0.00**	**0.00**	**0.21**
3 Years of ULEV Sales**	**0.52**	**2.43**	**0.21**
3 Years of SULEV Sales**	**0.96**	**3.43**	**0.52**

Cost Analysis:

Differential Capital Cost for a Honda CRV SULEV Hybrid Vehicle = $6000.
Lower Emission Factors Apply for the First 120,000 miles of Travel.
This yields a capital cost difference of $.05/mile for the SULEV.
Gas Mileage for a Honda CRV Hybrid is 51 mpg vs 39 mpg for a Conventional CRV.
At $2.00 per gallon for gasoline, this yields a cost of $.039/mile vs. $.051/mile.
The Capital Cost Differential Minus the Fuel Savings = $.038/mile.

	VOC ($/ton)	CO ($/ton)	NOX ($/ton)
Emission Reduction Costs			
3 Years of SULEV Sales**	**$530,831**	**$14,377**	**$690,080**

Footnotes:
Emissions for 2007 were calculated using MOBILE6, Version Jan 16, 2002.
The National Default Fleet VMT mix fraction is
0.3947 for LDGV, 0.3556 for LDGT12, and 0.1213 for LDGT34.
** Each year of vehicle sales is assumed to replace 7% of LDVs (National Average)

3.14 Improve Transit

Improving transit can involve either adding rail service or improving bus service. It is not likely that a new rail system could be designed and built anywhere in Tennessee by 2007, so only improved bus service was considered. Improved bus service would require adding new buses traveling either existing routes, more often, or new routes. Potential emission reductions of NOx can be calculated as follows.

A new 2006 model bus will emit 9.49 g/mile of NOx and will travel 124 miles per day (both values taken from MOBILE6). Assuming an average of 20 passengers on the bus at all times, yields an estimated 2500 passenger-miles of travel per bus per day. Assuming a worst-case vehicle occupancy rate of 1 person/vehicle, means that a single bus can offset 2500 vehicle-miles of travel by light-duty vehicles (assuming everyone riding the bus would otherwise drive a car or light truck. Light-duty vehicles in 2007 will emit an average of 0.904 g/mile of NOx (using National default MOBILE6 inputs).

Daily bus emissions: 124 bus-miles/day x 9.49 g/mile = 1177 g/day NOx

Light-duty vehicle emissions offset: 2500 veh-miles/day x 0.904 g/mile = 2260 g/day

Net emission reduction per bus: 2260 – 1177 = 1083 g/day NOx per bus

For 100 buses, the net emission reduction would be 108.3 kg/day or 0.12 tons/day NOx

EPAs Transportation Air Quality Web Site www.epa.gov/otaq/transp/traqmodl.htm contains a report on the emission reductions and costs of 24 CMAQ projects. A table summarizing the costs per ton of NOx emissions reduced is presented in the appendix of this report. The cost of emission reductions from 6 transit improvement programs in Pennsylvania, Georgia, Maryland, and Texas are listed in the table and range from $14,000 to $425,000 per ton of NOx reduced.

3.15 High Occupancy Vehicle Lanes

High occupancy vehicle (HOV) lanes have been built in many cities to encourage carpooling and ridesharing during the commute to work (and return) trip. HOV lanes are usually extra lanes built on freeways that require at least 2 occupants in a vehicle to use. Hours of use are generally limited to 4 hours during the morning peak hour and 4 hours during the afternoon peak hour. During off-peak hours, all vehicles may utilize the lanes. Some HOV lanes are constructed with special access ramps allowing reversible traffic flow in the morning and afternoons. HOV lanes are one part of a larger program to encourage ridesharing in order to reduce congestion and VMT.

A single HOV lane has a maximum hourly capacity of 2400 vehicles, or about 10,000 vehicles per peak traffic period. Each high occupancy vehicle may be considered to have eliminated a second vehicle trip because of ridesharing. If each avoided vehicle round trip was 20 miles, then the total avoided VMT is 200,000 (vehicle-miles/day). The composite emission factor for LDVs for 2007 is 0.9 g/mile of NOx and 1.3 g/mile VOC. The total quantity of emissions reduced is 0.20 tons/day of NOx and 0.29 tons/day of VOC. This may overestimate the emission reductions as many of the HOVs will not be new HOVs, but are part of the existing fleet (i.e. not all vehicles with 2 or more occupants represents an avoided commuting trip). Assuming a million dollars per year amortized cost to construct an HOV lane, yields a cost of $19,000/ton of NOx reduced and $13,000/ton of VOC reduced.

HOV lanes may require many years to design and construct. It is not likely that new HOV lanes could be planned and constructed in Tennessee EAC areas before 2007, so additional emission reductions achievable by this method are probably zero.

3.16 Traffic Flow Improvement Programs

Traffic flow improvement programs generally involve traffic signal synchronization designed to minimize stop-and-go travel thereby shortening delays and increasing average route speeds. These projects are applicable only on arterial roads with many traffic lights. Using the MOBILE6 model to estimate the change in emissions due to traffic flow improvements generally results in a predicted increase in NOx emissions (especially if speeds are increased above 35 mph). Two papers presented at the Transportation Research Board annual meeting in Washington, D.C. in January 2003 presented a different finding. Both these papers showed that NOx and VOC emissions may be reduced as a result of traffic signal synchronization (paper references are given in the footnote below). One paper presented the results of research with modal models that predict the effects of traffic flow improvements. The other paper presented the results of research using on-board tailpipe exhaust monitoring equipment on vehicles traveling corridors with and without traffic signal synchronization. In general, the results of these studies indicated that about 4% reduction in NOx and VOC emissions was achievable with traffic flow improvements. Emission reductions were not achieved on highly congested roadways where the effects of traffic signal synchronization were not fully realized (i.e. roads so congested that traffic signal synchronization did not improve traffic flow). The emission reductions were greatest when traffic volumes were moderate so that the full effect of traffic signal synchronization was realized.

Emission reductions achievable with traffic flow improvements can be estimated as follows. Interstates and local streets have none or few traffic lights. Therefore, only urban arterials with many traffic signals are candidates for flow improvements by traffic signal synchronization. In an EAC like Knoxville, 11.01 tons/day of NOx and 11.36 tons/day of VOC emissions occur on urban arterials. If 10% of all arterials are subject to traffic flow improvements, a 4% reduction could be achieved in emissions from these arterials. For the Knoxville EAC this would equal 0.044 tons/day of NOx and 0.045 tons/day of VOC. This is equivalent to a 0.03% reduction in area-wide NOx emissions. It is not likely that all urban arterials in the Knoxville EAC would be candidates for traffic signal synchronization. It is also likely that many traffic flow improvement projects may have already been undertaken and do not represent a potential for future emission reductions. The actual potential emission reductions from traffic flow improvement may be less than estimated above.

EPA's Transportation Air Quality Web Site www.epa.gov/otaq/transp/traqmodl.htm contains a report on the emission reductions and costs of 24 CMAQ projects. A table summarizing the costs per ton of NOx emissions reduced is presented in the appendix of this report. One project in Pennsylvania involved "arterial street signal interconnecting" was estimated to have achieved 2.01 tons/yr reduction in NOx emissions at a cost of $102,000 per ton. The costs for other signal synchronization projects were not given.

"Effect of Arterial Signalization and Level of Service on Measured Vehicle Emissions" by U. Alper, N. Rouphail, and C. Frey, North Carolina State University, TRB Paper No. 03-2884, Transportation Research Board Meeting, Washington, D.C., Jan 12-16, 2003.

"Evaluation of Simulation Models for Project-Level Emissions Analysis", by S. Hallmark, and S Poska, Iowa State University and K. Kosman LSC Transportation Consultants, TRB Paper No. 03-3925, Transportation Research Board Meeting, Washington, D.C., Jan 12-16, 2003.

3.17 Area-wide Rideshare Incentives

Rideshare incentives include programs to advertise the benefits of ridesharing and carpooling, providing vans and/or low cost parking spaces, and offering a phone number to call a clearinghouse to help find compatible carpoolers. These measures reduce traffic congestion and benefit air quality by reducing the vehicle miles traveled on the commute to work and the return trip. Travel demand modeling or other means must be employed to estimate the percentage of VMT reduction expected from ridesharing. The percent VMT reduction can be used to estimate the expected percent NOx emission reduction as follows.

In an EAC like Knoxville, 45.2% of NOx emissions are from on-road mobile sources. Forty percent of the on-road mobile emissions are from light duty vehicles including cars, vans, pickup trucks, and SUVs that would be used for commuting to school or work. It is likely that ridesharing will eliminate only light-duty vehicle trips. Therefore, for each 1 percent reduction in light duty vehicle VMT, NOx emissions will be reduced by 1% x .452 x .40 = 0.18%. Knoxville EAC NOx emissions for 2007 have been predicted to be 158 tons/day, so a 1% reduction in light-vehicle VMT would reduce NOx emissions by 0.18% x 158 tons/day = 0.28 tons/day throughout the Knoxville EAC area.

Fifty-seven percent of on-road NOx emissions are from heavy-duty trucks which will be unaffected by ridesharing programs.

EPA's Transportation Air Quality Web Site www.epa.gov/otaq/transp/traqmodl.htm contains a report on the emission reductions and costs of 24 CMAQ projects. A table summarizing the costs per ton of NOx emissions reduced is presented in the appendix of this report. The cost of emission reductions from 5 ride-share programs in California, Georgia, Maryland and Texas ranged from $16,000 to $158,000 per ton of NOx reduced.

3.18 Parking Management with Preference to Car/Vanpools

Parking management programs which give preference to carpools and vanpools must offer some kind of incentive to carpool or vanpool and a disincentive for one person to drive a vehicle alone. These incentives can involve differential pricing, bans on parking by vehicles with a single occupant, or just preferential locations for multi-occupant vehicles. If parking capacity in an area is severely limited, then preference can be given to multi-occupant vehicles. Such programs may be managed using parking permits and hang tags identifying program participants, or by other means. Parking management programs with preference to car/vanpools are usually a component of a larger program to encourage area-wide ridesharing in order to reduce congestion and VMT.

Emission reductions achievable through parking management with preference to car/vanpools can be estimated as follows. Assume that parking management programs with preference to car/vanpools primarily affects the commute to work (and return home) trips. Assuming the occupancy rate of vehicles used in the program is 3 persons/vehicle (versus 1 person per vehicle without the program), the number of vehicle trips is reduced by 2/3. For every 1000 persons ridesharing, 666 trips/day will be avoided. If each avoided vehicle round trip is 20 miles, then the total avoided VMT is 13,320 (vehicle-miles/day) per 333 commuter vehicles requiring a vanpool only parking space. The composite emission factor for LDVs for 2007 is 0.9 g/mile of NOx and 1.3 g/mile VOC. The total quantity of emissions reduced is 0.013 tons/day of NOx and 0.018 tons/day of VOC per 333 vanpool only parking spaces or 1000 participants. This may overestimate the emission reductions as many people already rideshare and will therefore not constitute additional emission reductions.

In order to estimate the cost, assume a government agency obtains a $50,000 grant to administer and promote the program. Assume the program results in 1000 vanpool only parking spaces being established in an area. Assuming 2000 twenty-mile vehicle trips are avoided each day, the VMT is reduced by 40,000 vehicle-miles/day. This yields an emission reduction of 0.039 tons/day of NOx and 0.054 tons/day of VOC. The emission reductions would be 14.2 tons/yr of NOx and 19.7 tons/yr of VOC (based on 365 days/yr). The cost to the government agency is approximately $3500/ton NOx reduced and $2500/ton of VOC reduced. These costs do not include the cost to the parking lot owner who may find his parking lot occupancy rate substantially reduced, which may be detrimental to commercial parking lots. Private use lots may actually save money by not needed to provide as much parking for customers.

3.19 Work Schedule Changes to Reduce Peak Demand

Work schedule changes designed to reduce peak demand generally involve flexible employee schedules where employees can alter the normal 9 am to 5 pm work shift to fit their own preferences. Some occupations do not work well with flexible employee schedules, while others may. Coming to work unusually early and leaving early help reduce peak hour traffic, but do not necessarily reduce trip distance and VMT. In order to accomplish a reduction in air pollution emissions a change in work schedule is needed which has the potential to reduce VMT. Examples of work changes that may reduce VMT are working four 10-hour shifts per week instead of five 8-hour shifts; or working at home on 2 or 3 days per week (sometimes call telecommuting). Working 4 days per week instead of 5 may reduce VMT by eliminating one home to work and back commute each week. Telecommuting more than one day per week has the potential to reduce the number of weekly commutes even more. However, there is some evidence that people working at home may tend to do more non-work related driving (especially at the end of the work day) than those who spend the day at the office or factory.

In order to estimate the emission reductions achievable by rescheduling work, an estimate of the VMT reduction that results is needed. It can be estimated that one commute-to-work-and-back can be eliminated per week for each person participating in the program. A distance of 10 miles each way is probably typical in Tennessee. People choosing to reschedule work to 4 days per week instead of 5 days per week might then reduce their VMT by 20 miles per week, or 4 miles/weekday. This means that a total of 4 miles/day of travel might be reduced from automobiles for each person participating. For every 1000 people participate, a maximum of 4,000 vehicle miles of travel (VMT) could be diverted from highways to bicycles each workday. It is likely that only light-duty gasoline vehicle trips would be eliminated. The average NOx emission factor for light-duty gasoline vehicles and trucks for 2007 is 0.904 g/mile. Daily NOx emissions reductions would equal:

4,000 VMT/day x 0.904 g/mile = 3616 g/day or 0.004 tons/day per 1000 participants

The cost of NOx emission reductions obtained from a program to promote work schedule changes is difficult to estimate. One crude estimate would be approximate the cost to operate and maintain a small staff and purchase advertising to promote work schedule changes, along with an assumed success rate or participation rate. If $40,000 was spent each year to promote work schedule changes, and if eventually 10,000 people participate, then $40,000/yr will be spent to achieve 0.04 tons/yr of NOx reduction. This cost is equal to $1,000,000 per ton.

3.20 Employer-Based Transportation Management Plans

Employer-based transportation management plans can be used to encourage carpooling and ridesharing during the commute to work (and return) trip. In these programs the responsibility is placed on the employer to develop plans and means to encourage employees to rideshare to work. Some companies actually purchase or subsidize the cost of passenger vans that employees use for commuting to and from work. Government agencies may require employers to prepare and submit transportation management plans, or the activities may be completely voluntary. Employer-based transportation management plans are usually a component of a larger program to encourage area-wide ridesharing in order to reduce congestion and VMT.

Emission reductions achievable through employer-based transportation plans can be estimated as follows. Assuming the occupancy rate of vehicles used in the program is 3 persons/vehicle (versus 1 person per vehicle without the program), the number of vehicle trips (commuting to and from work) is reduced by 2/3. For every 1000 employees participating in the program, 666 trips/day will be avoided. If each avoided vehicle round trip is 20 miles, then the total avoided VMT is 13,320 (vehicle-miles/day) per 1000 participants. The composite emission factor for LDVs for 2007 is 0.9 g/mile of NOx and 1.3 g/mile VOC. The total quantity of emissions reduced is 0.013 tons/day of NOx and 0.018 tons/day of VOC per 1000 participants. This may overestimate the emission reductions as many employees already rideshare to work and will therefore not constitute additional emission reductions. However, these employees would probably participate in the program in order to obtain the benefits of employer offered travel subsidies, preferred parking spaces, etc.

In order to estimate the cost, assume a government agency obtains a $50,000 grant to administer and promote the program. If 10,000 employees participate, then the emission reductions would be 34 tons/yr of NOx and 48 tons/yr of VOC. The cost to the government agency is approximately $1500/ton NOx reduced and $1000/ton of VOC reduced. These costs do not include the cost to the employer that is difficult to estimate. Costs to the employer may entail as little as directives to employees to rideshare (low cost example), or employers may decide to purchases passenger vans for employee use (high cost example). For employers which decide to subsidize the cost of passenger vans, a typical cost might be $.30/mile. Assuming an average of 30 miles/day traveled per vehicle, and 3,333 vehicles required per 10,000 participants, the cost to employers would be $30,000/day. At this rate, the cost of emission reductions is $230,000/ton NOx and $167,000/ton VOC. In any case, it is not likely that employers will be pleased to be required by a government agency to plan for their employee's transportation or to incur the cost. Of course the cost to the employer is actually a savings to the employee.

3.21 Bike Trails and Bike Racks at Work Sites

Bike trails and bike racks at work sites are intended to encourage bicycle riding in lieu of driving a vehicle to and from work or school. Many cities have constructed networks of bike trails and pedestrian walkways that are very popular and frequently used. These uses tend to be more recreational, however than for work purposes. In fact the bike and pedestrian trails can become trip attractors that generate new trips to access the trails. For bike trails and pedestrian walkways to contribute to air pollution emission reductions, they will have to be used as a substitute for the commute to work or school trip (or a shopping trip) that will reduce vehicle miles of travel by gasoline fueled vehicles.

In order to estimate the emission reductions achievable by bike and pedestrian trail construction, an estimate of the VMT reduction that results is needed. A typical bicycling speed is 10 miles/hour. People choosing to bike to work may be willing to ride an average of 30 minutes each way. This means that a total of 10 miles/day of travel might be diverted from automobiles to bicycling if a sufficient network of proper bike trails were available. For every 1000 people who switch from driving to bicycling to work, a maximum of 10,000 vehicle miles of travel (VMT) could be diverted from highways to bicycles. It is likely that only light-duty gasoline vehicle trips would be eliminated. The average NOx emission factor for light-duty gasoline vehicles and trucks for 2007 is 0.904 g/mile. Daily NOx emissions reductions would equal:

10,000 VMT/day x 0.904 g/mile = 9040 g/day or 0.01 tons/day per 1000 bicyclists

EPA's Transportation Air Quality Web Site www.epa.gov/otaq/transp/traqmodl.htm contains a report on the emission reductions and costs of 24 CMAQ projects. A table summarizing the costs per ton of NOx emissions reduced is presented in the appendix of this report. The cost of emission reductions from a bicycle/pedestrian network in Philadelphia is presented in that report. The NOx emission reductions estimated for the project were 0.018 tons/day for both bicycle and walking trails. The cost was $298,000 per year or $46,500 per ton of NOx reduced.

3.22 Pedestrian Greenways

Pedestrian greenways and walkways can reduce air pollution emissions only to the extent that people walk to a destination that they would otherwise have driven to. If pedestrian walkways can provide an alternative means of travel to light-duty gasoline vehicles, then every person-mile of walking may reduce vehicle-miles of travel by a less than or equal amount (depending on vehicle occupancy rates). Any reduction in vehicle-miles of travel can be used to estimate the expected NOx emission reduction as follows.

A typical walking speed is 2 miles/hour. People choosing to walk to work may be willing to walk an average of 30 minutes each way. This means that a total of 2 miles/day of travel might be diverted from automobiles to walking if proper walking facilities were available. For every 1000 people who switch from driving to walking to work, a maximum of 2000 vehicle miles of travel (VMT) could be diverted from highways to walking. It is likely that only light-duty gasoline vehicle trips would be eliminated. The average NOx emission factor for light-duty gasoline vehicles and trucks for 2007 is 0.904 g/mile. Daily NOx emissions reductions would equal:

2000 VMT/day x 0.904 g/mile = 1808 g/day or 0.002 tons/day per 1000 walkers

EPA's Transportation Air Quality Web Site www.epa.gov/otaq/transp/traqmodl.htm contains a report on the emission reductions and costs of 24 CMAQ projects. A table summarizing the costs per ton of NOx emissions reduced is presented in the appendix of this report. The cost of emission reductions from a bicycle/pedestrian network in Philadelphia is presented in that report. The NOx emission reductions estimated for the project were 0.018 tons/day for both bicycle and walking trails. The cost was $298,000 per year or $46,500 per ton of NOx reduced.

3.23 Truck Stop Electrification (TSE), an Alternative to Idling

3.23.1 Introduction

Long haul truck drivers generally idle their heavy duty diesel vehicle engines while parked at travel centers during required rest periods. The engines are operated in the idling mode to keep the engines warm during cold weather and to provide on board electrical power for appliances and to provide heat and air conditioning for the truck cab and sleeper compartment.

Up to one gallon of diesel fuel per hour is used by a typical diesel truck while idling, due to the fact that the truck must be maintained in a high idle mode to minimize damage to the engine. This results in as much as 2,400 gallons of fuel every year per truck. In addition, idling increases engine wear and contributes to emissions of major pollutants. On average, each idling truck produces about 21 tons of carbon dioxide (CO_2) and 0.3 tons of nitrogen oxides (NO_x) annually, resulting in total emissions from idling trucks of over 11 million tons and 150,000 tons, respectively [1].

The fuel consumed during idling can be saved and air emissions reduced by installing "idle reduction technology," a technology that allows the truck driver to avoid idling of the engine. One alternative is Truck Stop Electrification (TSE), which saves fuel and reduces emissions. One local example of TSE technology is that provided by IdleAire, Inc. that provides a connection to the truck cab through the passenger side window. The connection includes thermostatically controlled heat and air conditioning, electricity and cable at each truck parking space via an overhead rack that spans the parking area. The electrification devices allow drivers to power heat or air conditioning appliances, without running their engines. Once installed, the system is operated on a fixed fee per visit basis that essentially pays for itself in that that the cost is offset by the savings in fuel.

3.23.2 Methodology & Assumptions

Based on discussion with IdleAire and estimates used in a recent CMAQ grant made by Knox County TN to IdleAire, the initial capital cost of electrification parking spaces for 100 heavy duty diesel trucks is approximately $1,000,000 and the equipment life is expected to be 20 years. For purposes of calculation in this report, each space is assumed to have an occupancy rate of 16 hours/day or two-thirds of a day (or 0.667).

The emissions (grams/hour/truck) for idling conditions for heavy-duty diesel vehicles (truck category HDDV 8b) were estimated using the EPA-recommended procedure of obtaining the emissions by running the MOBILE6 model for a speed of 2.5 mph for the arterial roadways category. All other parameters were set to default national fleet settings.

A brief literature review was also conducted to confirm that the emission estimate using the above approach was reasonable based on reported emissions from idling diesel trucks. The literature review revealed that actual testing of truck idling emission in the 1990's showed average idling emission rates of 155 grams/hour/truck (ranging from 95 to 225 grams/hour/truck). This value is greater than the 47 grams/hour/truck value obtained from MOBILE6 for 2007, however that is likely reasonable, since emissions from diesel engines will decrease in the future due to improved technologies and low sulfur diesel fuel programs. While the 2007 value of 47 g/h was used in the calculations, it should be noted that the actual emission reduction achievable may be greater if TSE is implemented earlier than 2007 or it the emissions end up being greater than that predicted by MOBILE6. In that case, the estimated cost per ton of reduction may also be lower.

3.23.3 Calculations

The cost per ton of emission reduction is calculated as follows:

1. The emission factor in grams/mile/truck is converted to grams/hour/truck by multiplying by 2.5miles/hour.

2. The gram of pollutant per hour for a single truck is changed to gram of pollutant per day for 100 trucks by multiplying by 24 and 100.

3. The calculated grams of pollutant is converted to tons and an occupancy factor of 0.667 is applied to take into account the assumed occupancy at the TSE travel center.

4. Eventually multiplying the resulting quantity by number days in a year, the unit will result in tons/year/100 trucks.

5. The cost per ton of emission reduction is obtained by dividing the cost per annum by tons of emission/year/100 trucks.

The emission reduction and cost estimate are summarized in Table 3.23.1. As shown in the table, the estimated cost of the strategy is approximately $1660/ton of NOx reduced, if the entire cost is based on NOx reduction and it is assumed that there is no net expense to the driver once it is installed due to the savings in fuel. The cost is lower if one looks at the cost per ton of all pollutants, or if one looks at the current emissions from diesel trucks.

References:

[1]. http://www.epa.gov/otaq/retrofit/idling.htm browsed April 1, 2003.

Table 3.23.1 Truck Electrification Emission Reduction and Cost

MOBILE6 Model Inputs:

Calendar Year:	2007
Month:	July
Altitude:	Low
Minimum Temperature:	60.0 (F)
Maximum Temperature:	93.0 (F)
Absolute Humidity:	75. Grains/lb
Nominal Fuel RVP:	9.0 psi
Weathered RVP:	8.6 psi
Fuel Sulfur Content:	33.0 ppm
Exhaust I/M Program:	No
Evap I/M Program:	No
ATP Program:	No
Reformulated Gas:	No

Initial cap Costs/100 trucks	1,000,000	$				
Eqp life	20	Years				
Per annum costs/100 trucks	50000	$				
Utilization Factor	0.66					
Vehicle Type	**HDDV 8b**					
Emission Factors	**Grams/mile**	**Miles/hr**	**Grams/hr**	**Tons/day/100 Trucks**	**Tons/year/100 Trucks**	**$/Ton Emission Reduction**
Composite VOC			4.47925	0.007820913	2.9	17515.4
Composite CO			39.652	0.069233651	25.3	1978.6
Composite NOX			47.167	0.082355079	30.1	1663.4
1990s truck emissions			225	0.392857143	143.4	348.7

ASSUMPTIONS

Assume the utilization factor for Electrification Slot as 0.66 (used effectively two-third of a day).
Assume the Initial capital cost of Electrification Slot for 100 Trucks is $1,000,000.
Assume the equipment life to be around 20 years.

CALCULATION

Therefore the cost involved in TSE/annum for 100 trucks is $50,000.
Emission factor (grams/mile) is calculated by running the model for National settings with 2.5 mph.
Emission factor (grams/mile) * Speed (miles/hr) = **grams of pollutant/hour/truck.**
Convert **grams/hour/truck** to **Tons/day/100 trucks.**

Tons/day/100 trucks = ((grams/hour/truck)*24*0.66*100)/90700.

Convert **Tons/day/100 trucks** to **Tons/year/100 trucks.**
Cost involved / Ton Emission Reduction = ($50,000/Tons/year/100 trucks).

3.24 Programs to Encourage Removal of Pre-1980 Vehicles and Super-emitters

Various programs have been developed in California and other states to attempt to identify high emitting vehicles and remove them from the vehicle fleet. Many of these high emission vehicles are old vehicles without air pollution control equipment, vehicles that have had air pollution controls removed (by tampering), and old vehicles with air pollution controls but not properly maintained. Numerous studies have shown that so called "super-emitters" contribute significantly to air pollution emissions. Various means to identify these vehicles can be used including the use of remote sensing of emissions by roadside instruments, requiring tailpipe testing of impounded vehicles, police ticketing of smoking vehicles, and routine testing of vehicles through a regular inspection and maintenance (I/M) program. To eliminate the vehicles from the fleet, vehicles repeatedly failing I/M tests and super-emitters detected by remote sensing can be denied registration. In some areas, super-emitters are purchased from the owners (often low-income individuals) and scrapped. Money to purchase super-emitters can be provided by a private sponsor or government agency. Higher licensing fees and other means can be used to provide the funding for such a program. Vehicles are usually purchased at a price that provides a subsidy for the purchase of another vehicle, but usually not enough to cover the entire cost. Usually the price paid to scrap an old vehicle is $1000 or less.

The attached table shows an estimate of the emission reductions potentially achievable from removing vehicles 25-years old and older, based on emission factors obtained from the MOBILE6 model. Vehicles 25-years old and older are grouped in a single category in the MOBILE6 model and have higher emissions than all other vehicles (<25-years old) in each vehicle type class. Generally, old vehicle purchases are restricted to light-duty gasoline vehicles (LDGVs) and light-duty gasoline trucks (LDGTs) which include vans, pickup trucks, and SUVs.

For purposes of estimating emission reductions, all light-duty gasoline vehicles were grouped together based on the National default vehicle type distribution (VMT fraction) as "built-in" to the MOBILE6 model for calendar year 2007. As shown in the table, the emissions from composite light-duty vehicles >25-years old is 2.6, 44.8, and 2.5 g/mile for VOC, CO and NOx, respectively. EPA guidance (*Guidance for the Implementation of Accelerated Retirement of Vehicles Programs – EPA420-R-93-018 February 1993)* states that credits should be calculated assuming an old vehicle will be replaced with a used (not new) vehicle with emission factors equal to the average composite fleet. The composite emission factors for vehicles of all ages for 2007 is 1.1, 11.9, and 1.8 g/mile for VOC, CO and NOx, respectively (as shown in the attached table). The credit for retiring an old vehicle is the difference between these emission factors, equal to 1.4, 32.1, and 1.6 g/mile for VOC, CO and NOx, respectively.

According to the annual mileage accumulation rates given in MOBILE6, 25-year old light-duty gasoline vehicles are typically driven approximate 4000 miles/year. The emission credit (i.e. reduction) in g/mile times 4000 miles/year yields the emission credit in g/year. Values shown in the attached table show the emission credits in tons/year and tons/day for 1000 vehicles scrapped. The emissions reductions per 1000 vehicles scrapped is 0.017, 0.388, and 0.019 tons/day for VOC, CO, and NOx, respectively.

EPA only allows the emission credits for three years, stating that old vehicles would eventually be scrapped anyway, and that the program only accomplishes an earlier than normal retirement by 3 years. EPA further requires that the credit be reduced by 20% in the second year and 40% in the third year. Given the required discounting of credit, the total emission reduction over 3 years is equal to the first year credit times 2.4. The total emission reductions per 1000 vehicles scrapped over 3 years is 15.1 tons of VOC, 340 tons of CO, and 16.9 tons of NOx. If the cost per vehicle scrapped is equal to $1000/vehicle, then the cost to scrap 1000 vehicles is $1 million. The cost of emissions reductions from accelerated retirement of old vehicles is then $66,250/ton VOC, $2945/ton CO, and $59,000/ton NOx.

In Tennessee, approximately 4% of light-duty vehicles are 25-years old or older. The percentage is higher in low-income counties (some >6%), and lower in high-income counties. There are 5 million vehicles registered in Tennessee. If 4% are 25-years old or older, then the total number of old vehicles in the state fleet is 200,000. Accomplishing early retirement of these vehicles would cost $200 million. The primary impediment to the implementation of an early retirement program is finding the necessary money to pay for the program. A state or local government program to raise the funds by taxes or license fees would be required, or a private sponsor must be found to pay for the program. In California, utility companies have sponsored such programs, but they have retained a portion of the emission credits to use against their actual emissions. Substantial costs can also be incurred in administering early retirement programs which must meet many complicated rules to insure that the vehicles purchased are not just wrecked or junk cars that would have been scrapped anyway.

Calculation of Potential Emission Reductions From Scrapping >25-Year Old Passenger Vehicles

	VMT Fraction	VOC (g/mile)	CO (g/mile)	NOx (g/mile)
		2007 Emission Factors For 25-Year Old Passenger Vehicles		
LDGV	0.3947	1.724	32.352	2.56
LDGT12	0.3556	3.227	54.054	2.458
LDGT34	0.1213	3.457	57.994	2.477
Composite of LDVs	0.8716	**2.578**	**44.775**	**2.507**
		2007 Emission Factors For the Passenger Vehicle Fleet		
LDGV	0.3947	1.015	11.09	0.749
LDGT12	0.3556	1.071	12.8	0.928
LDGT34	0.1213	1.826	17.32	1.34
Composite of LDVs	0.8716	**1.151**	**12.655**	**0.904**
National Default Fleet	1.000	1.115	11.854	1.787

	VOC (g/mile)	CO (g/mile)	NOx (g/mile)
Emission Reductions From Eliminating 25-Year Old Vehicles	1.428	32.120	1.603

	VOC (tons/year)	CO (tons/year)	NOx (tons/year)
Annual Emission Reductions Per 1000 Vehicles Scrapped (4000 miles/veh-yr)	6.29	141.50	7.06

	VOC (tons/day)	CO (tons/day)	NOx (tons/day)
Annual Emission Reductions Per 1000 Vehicles Scrapped (4000 miles/veh-yr)	0.017	0.388	0.019

	VOC ($/ton)	CO ($/ton)	NOx ($/ton)
Cost per Ton of Emissions Reduced Over 3 Years (basis: $1000/veh) EPA requires 20% discount of credit	66,250	2,945	59,020

APPENDICES

Criteria for Transportation Control Measures to be Included in SIPs
(taken from EPA 450/2-89-020, Sept. 1990)

1. A complete description of the measure and its estimated emissions reduction benefits.
2. Evidence that the measure was properly adopted by a jurisdiction with legal authority to commit to and execute the measure.
3. Evidence that funding has been (or will be) obligated to implement the measure.
4. Evidence that all necessary approvals have been obtained from all appropriate government agencies (including MPO and State transportation departments, if applicable).
5. Evidence that a complete schedule to plan, implement, and enforce the measure has been adopted by the implementing agency or agencies.
6. A description of the monitoring program to assess the measures' effectiveness and to allow for necessary in-place corrections or alterations.
7. Governor's approval of SIP{.
8. Public hearing (as part of the SIP approval process).

Summary Review of Costs and Emission Reductions for 24 CMAQ (Congestion Mitigation and Air Quality) Projects

(Full report (9/28/99) available on EPAs Transportation Air Quality Web Site, www.epa.gov/otaq/transp/traqmodl.htm)

Category	Project Name	State	NOx Emission Reduction (tons/yr)	Project Annual Cost ($/year)	Annual Cost Per Ton NOx ($/ton)	National Median Emission Reduction (tons/yr)	NOx Emission Reduction (tons/day)
Shared Ride	Commuter Assistence Program	CA	2.64	417,400	158,106	1.9	0.007
	Glendale Parking Management Program	CA	5.04	104,500	20,734		0.014
	University Rideshare Program	GA	4.00	106,800	26,700		0.011
	Park-n-Ride Facility	MD	1.00	16,100	16,100		0.003
	Regional Vanpool Program	TX	62.00	1,700,000	27,419		0.170
Bike/Ped	Philadelphia Bicycle Network	PA	6.41	298,000	46,490	0.27	0.018
	Suburban Bike Rack Incentives	IL		26,600			
Traffic Flow	Arterial Street Signal Interconnect	PA	2.09	214,000	102,392	0.55	0.006
	Signal Systemization Along MD2	MD		6,300			
	Incident Management Program	GA	158.00	841,300	5,325		0.433
	Signal Interconnection Project	IL		32,000			
	Extension of HOV Lanes	CT	1.10	1,436,000	1,305,455		0.003
Transit	Lake Cook Shuttle Bug	IL		390,000		1.92	
	Houston Transit Subsidy	TX	34.75	3,500,000	100,719		0.095
	Light Rail Vehicles	MD	20.84	6,964,000	334,165		0.057
	University City 30th St Circulator	PA	0.80	340,000	425,000		0.002
	Commuter Rail Coaches	MD	93.20	7,236,000	77,639		0.255
	MARTA Intelligent Transportation Sys	GA	2.25	31,500	14,000		0.006
	MARTA Transit Incentives	GA	16.75	375,000	22,388		0.046
TDM	Long Island TDM Program	NY	6.94	450,000	64,841	12.65	0.019
	IEPA Public Education & Outreach	IL		293,000			
	Atlanta Region TMA's	GA	26.50	299,000	11,283		0.073
Other	Fairfax Co. Alternative Fuel Vehicle Prog	VA	0.02	128,000	6,400,000	0.55	0.000
	Alternative Fuels Refueling Station	GA	2.00	23,600	11,800		0.005
Scrap Old Veh's	Programs to Scrap 1,000 Old Vehs/Yr	3-Yr Credit	10.00	7,500,000	750,000		0.027

NOx Emission Reductions Potentially Achievable by Various Control Measures (Georgia)

Control Measures Evaluated for the 13-County Atlanta Ozone Nonattainment Area
by Georgia State University - Copy obtained from Mark Corrigan of TDEC

Total NOx Emissions From the 13-County Area for 1999 were 216,000 tons/year or 592 tons/day.
(Note: Not all of these measures were included in the SIP)

Control Measure	NOx Reduction (tons/day)	Cost Effectiveness ($/ton)	Percent NOx Reduction Area-Wide
Oxygen Firing at Glass Mfg Plants	2.73	3725	0.46
Low NOx Burners on Selected Industries	2.26	1200	0.38
Low Excess Air (Oil/Gas Commercial & Indus Boilers)	6.37	3500	1.08
LNB w LPG, FGR, RB, WI, on Res, Com, & Ind Furnaces (Considered to be cost prohibitive)	54.26	8000	9.17
CA Reformulated Diesel Fuel for Onroad Vehicle (Considered to be cost prohibitive)	8.96	6000	1.51
High Cetane Diesel Fuel for Onroad Vehicles (Considered to be cost prohibitive)	1.4	18000	0.24
Zero I/M Waivers and Exemptions	0.63	6000	0.11
Congession Pricing/Tolls: Choose One: $0.50/gal fuel tax, Pay-as-you-drive insurance $0.50/gal, VMT tax $0.02/mile, et. al. ($.02/mi x 1 mile/g NOx)	2.19	18000	0.37
Liqufied Natural Gas Dual Fuel for Railroad Switch Engines	3.05	1000	0.52
Incentives for Turnover of 2 and 4 Cycle Small Engines	1.27	NA	0.21
Total	**83.12**		**14.04**

LNB = Low NOx Burners
LPG = Liquified Petroleum Gas
NA = Not Available
FGR = Flue Gas Recirculation
RB = Radian Burners
WI = Water Injection

NOx Emission Reductions Potentially Achievable by Various Control Measures (California)

Control Measures Included in the Draft 2003 Air Quality Management Plan of the South Coast Air Quality Management District (Los Angeles)

Total NOx Emissions For the South Coast AQMD Area 2006 Baseline = 927 tons/day.

Control Measure	NOx Reduction (tons/day)	Percent NOx Reduction Area-Wide
Truck Electrification	2.1	0.23
CMB-10 RECLAIM Program (Regional Clean Air Incentives) (covers both powerplant & non-powerplant emissions)	3	0.32
HOV, Bicycle, Pedestrian, Rideshare, ITS, & Telecommute Programs	0.2	0.02
New Off-Road Diesel Engine Controls by 2010	0	0.00
New Off-Road Diesel Engine Controls by 2015	10	1.08
New Standards for Off-Road Gasoline Engines > 25 HP	4.3	0.46
Require Electric Forklifts	4.7	0.51
Smog Check I/M Improvements (halt the 30-yr old vehicle exemption)	8	0.86
Clean-Up the Existing Truck & Bus Fleet	11	1.19
Lawn & Garden Equipment (New Standards)	0.9	0.10
Subtotal	**44.2**	**4.77**
Total Reductions in the Plan for 2010 (740 ton/day baseline)	**210**	**28.4**

Bay Area TCMs and their effects

December 1998/January 1999

Reductions in Emissions for Transportation Control Measures

TCMs (transportation control measures) achieve very modest emission reductions when compared to the cuts needed to reach federal standards -- excluding transportation pricing reform, which requires legislative authorization, they save only one or two tons of emissions per day, or about 0.5 percent of the total mobile source ROG inventory.

	2005		2015	
Tons per day >	ROG	NOx	ROG	NOx
Support Voluntary Trip Reduction Programs				
(Maintain Current Efforts)	- 0 -	- 0 -	- 0 -	- 0 -
Improve Areawide Transit Service				
a) Transit Service (Maintain Current Efforts)	- 0 -	- 0 -	- 0 -	- 0 -
b) Clean-Fuel Transit Vehicles	0.01	0.01	<0.01	0.01
Improve Regional Rail Service	0.08	0.08	0.06	0.07
Improve Access to Rail and Ferries	0.04	0.03	0.03	0.03
Improve Interregional Rail Service	0.02	0.03	0.02	0.03
Improve Ferry Service	0.01	0.01	<0.01	0.01

Construct Carpool/Express Bus Lanes on Freeways	0.01	0.01	0.03	0.03
Improve Bicycle Access and Facilities	0.05	0.03	0.07	0.05
Youth Transportation				
a) School Bus Service	0.02	0.01	0.03	0.03
b) Clean-Fuel School Buses	0.01	0.04	0.01	0.03
Install Freeway/Arterial Metro Traffic Operations System	0.10	0.01	0.14	<0.01
Improve Arterial Traffic Management	0.10	0.05	0.20	0.12
Transit Use Incentives	0.13	0.11	0.21	0.16
Improve Rideshare/Vanpool Services and Incentives				
(Maintain Current Efforts)	- 0 -	- 0 -	- 0 -	- 0 -
Local Clean Air Plans, Policies and Programs	0.02	0.01	0.01	0.01
Intermittent Control Measure/Public Education				
(Maintain Current Efforts)	- 0 -	- 0 -	- 0 -	- 0 -
Conduct Demonstration Projects				
a) Clean Air Vehicle Demonstrations	0.02	0.04	0.01	0.04
b) Other Demonstrations	0	0	0	0
Transportation Pricing Reform	7.16	9.66	10.91	26.39
Pedestrian Travel	0.71	0.84	0.72	1.59

Promote Traffic Calming Measures	0.54	0.84	0.54	1.59
Total emissions reductions from TCMs	9.03	11.81	13.01	30.2

http://www.mtc.ca.gov/publications/transactions/ta1298-0199-htm/reductions.htm

LAWNMOWER BUY-BACK PROGRAM
(to be filled out for each mower exchanged)

Event Information:
Location:
Date: / /
Site Staff: ________________________________

Personal Information (please print):
Name: ___________________________________
Address: _________________________________
City: ______________________Zip:__________
Phone: (____)_____________________________

Retired Mower Information:
Make of mower: __________________________
Serial #: __________________________________
Horsepower of engine:______________________
Type of engine: 2 Stroke 4 Stroke
Age of mower (approx): __________ years
Average use per week (approx): _____ hours

I certify that I am the owner of the mower that I am turning in today.
Date: / /
Signature: ________________________________

....

Thank you for participating in the Lawnmower Buy-Back Program. Trading in your gas-powered mower in favor of an electric, battery or non-motorized mower helps to improve our region's air quality.

Bottom section to be filled out by consumer

Store Information (please print):
Store Name: _____________________________
Store Address: ____________________________
City: __________________ Zip:__________

New Mower Information:
Date of New Mower Purchase: / /00
Circle one: Electric Battery Non-motorized
Brand and Model: __________________________
Price of Mower: ___________________________

Print Name: _______________________________
Signature: ________________________________

Lawnmower Buy-Back Rules:

- **Original receipt** proof of purchase and completed rebate form must be mailed in within thirty days to receive rebate.
- Rebate amounts: Electric and Battery-$, Non-motorized mower-$.
- Rebates will be mailed approximately 60 days after the buy-back event.
- Rebates will not be paid on returns.

If you have any questions about the rebate process please call

Rebates are only available for the purchases of electric, battery, and non-motorized (push or reel) mowers. To receive your rebate, please **complete this form** and submit along with the **original receipt and proof of purchase** from your new electric, battery, or non-motorized mower to:

Lawnmower Buy-Back
(address here)

Lawnmower Buy Back Program

This reporting form is intended to provide the Clean Air Counts Campaign with information about the emission reduction activities of its adopters. The information we collect will allow us to calculate the benefits of each individual action. It may also be used to support air quality planning activities and promote emission reduction strategies in our region.

Contact Information

Please provide the following information for the person - or persons - that Clean Air Counts should contact regarding the success of this strategy.

First Name:

Last Name:

Organization:

Address:

City:

State:

Zip:

Phone:

Fax:

E-mail Address:

Project Description

The Lawnmower Buy Back Program aims to reduce air pollutants by encouraging people to trade in gas- powered mowers for electric, battery, or non-motorized mowers.

When did the Buy Back event occur:

Where did the Buy Back event occur:

Project Impacts

How many mowers were retired?

2 stroke: 0

4 stroke: 0

How many new mowers were purchased?

electric: 0

push (reel): 0

Please attach copies of the certification forms for the exchanged mowers.

How were old mowers destroyed?

scrapped: 0

drilling: 0

other: 0

Please attach copies of scrappage receipts or a letter verifying the destruction of the old mowers if applicable.

submit

http://www.cleanaircounts.org/default.cfm?page=lawnmower